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ABSTRACT

This report provides an overview of the research program of the Human Learning and Behavior Branch of the U.S. National Institute of Child Health and Human Development (NICHHD) and highlights progress made from 1985 through 1987. The Branch, one of five that together comprise the Center for Research for Mothers and Children of NICHHD, was established in 1977 and has as its primary mission the support of research and research training to gain a fundamental understanding of behavioral development. This goal is accomplished by funding grants and contracts which are in the aggregate designed to determine how the interaction of biological, psychological, and socioenvironmental factors results in normative development. Processes and behaviors from the perinatal period to the beginning of adulthood are studied across a wide diversity of mechanisms that range from the molecular to the molar, the basic to the applied and the normal to the pathological. The program is divided into five major elements: (1) behavioral pediatrics; (2) developmental behavioral biology; (3) learning; (4) cognition and social and affective development; and (5) communication. The report also briefly summarizes the workshops and conferences sponsored by the Branch. Requests for proposals issued during fiscal years 1985 through 1987 are also enumerated. (Six tables and nine graphs are attached.) (RH)

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# *A Report to the National Advisory Child Health and Human Development Council*

## *Human Learning and Behavior Branch Center for Research for Mothers and Children*

## *National Institute of Child Health and Human Development*

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*January 1988*

THE HUMAN LEARNING AND BEHAVIOR BRANCH

A Report to the
National Advisory Child Health and Human Development Council

January 1988

## EXECUTIVE SUMMARY

The attached narrative comprises the Human Learning and Behavior Branch's Report to the National Advisory Child Health and Human Development Council. The document provides an overview of the funding trends for the Branch from 1978 to the present. The report's emphasis is upon fiscal years 1985-1987.

A comprehensive summary of research highlights that covers accomplishments during fiscal years 1985-1987 is provided. This covers the five program areas supported by the Branch. These are: (a) Behavioral Pediatrics, (b) Developmental Behavioral Biology, (c) Learning, (d) Cognition and Social-Emotional Development and (e) Communication.

The summary of the behavioral pediatrics program discusses findings on neonatal behavior, health and illness related behavior of children and childhood injury. The developmental behavioral biology section focuses on progress made in brain/behavior relationships as shaped by hormonal influences. The section on learning describes studies of development during the perinatal period. The research summarized in the cognition and social emotional aspect of the program reviews findings on the socialization of emotion and cognition and the development of cognition during infancy and childhood. The research on communication is focused on the development of speech and language and dyslexia.

The report also briefly summarizes the workshops and conferences sponsored by the Branch. Requests for Proposals issued during FY 85 - FY 87 are also enumerated.

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## INTRODUCTION

This report provides an overview of the Human Learning and Behavior Branch program of research and highlights of progress made during the past three fiscal years (1985, 1986, 1987). The Branch, which was established in 1977, has as its primary mission the support of research and research training to gain a fundamental understanding of behavioral development. This goal is accomplished by funding grants and contracts which are in the aggregate designed to determine how the interaction of biological, psychological and socioenvironmental factors results in normative development. Processes and behaviors from the perinatal period to the beginning of adulthood are studied across a wide diversity of mechanisms that range from the molecular to the molar, the basic to the applied and the normal to the pathological.

The program is divided into five major elements: (1) Behavioral Pediatrics, (2) Developmental Behavioral Biology, (3) Learning, (4) Cognition and Social and Affective Development, and (5) Communication.

The Branch is one of five that together comprise the Center for Research for Mothers and Children (CRMC).

## TRENDS IN FUNDING

The Branch portfolio has grown during the last three fiscal years in both dollars and number of grants supported. This trend is shown in Table 1 and Figures 1 and 2. Table 1 describes HLB's relationship to the Institute and Center for Research for Mothers and Children during the decade from 1978-1987. The data reveal that between FY 78 and FY 87 the number of grants doubled from 106 to the present 214. Since our last report to the Council there is a trend for growth in the absolute number of projects supported. Specifically the portfolio contained 154 grants in FY 84. This number increased in each of the fiscal years since then and reveals what may be a trend that relates in part to a shift in early FY 85 to the percentiling method for determining funding by the Institute. Absolute dollar value of the Branch portfolio shows a parallel increase over the last three fiscal years. In FY 84 the HLB Branch holdings were $15.2 million. As of the end of FY 1987 that dollar amount increased to $24.4 million.

These trends are well depicted in Figure 1. In the last three fiscal years HLB's portfolio represented respectively 9, 9.8 and 10.3 percent of NICHD's holdings. The percentages of the Institute budget represented by Branch holdings during these three fiscal years were 6.6, 7.8 and 7.9 respectively. The growth in the last two fiscal years is the first break in the asymptotic pattern that characterized the Branch portfolio from FY 79 to FY 84.

A similar pattern is depicted in Figure 2. This plots the proportion of HLB's number and budget of grants supported compared to that of CRMC. In FY 85-87 the HLB held respectively 15.3, 16.3 and 16.8 percent of the

grants funded by the CRMC. During that same period the proportion of the budget for the Branch portfolio was 11, 12.7 and 12.8 percent.

Table 2 shows a breakdown of the Branch portfolio by funding mechanism since FY 1980. Regular research grants (R01) have systematically increased during the eight fiscal years described. The number of training grants awarded have also shown a trend upward. All other funding mechanisms have remained at an essentially asymptotic level. These trends are depicted graphically in Figure 3.

An analysis of funds expended by type of grant mechanism is shown in Table 3. The largest number of dollars goes to the category of investigator initiated grants. The next largest category is program projects (P01). The ratio of expenditures for R01s to those for P01s ranges from 2:1 - 3:1 over the eight fiscal years analyzed (see Figure 3).

Figure 4 shows a breakdown of HLB funds by program category within the research grant (R01 and P01) funding mechanism. In the past three fiscal years there has been a decline in the percent of funding devoted to the Behavioral Pediatrics programs. This change should be reversed in the next several fiscal years due to the five year funding agenda on childhood injury. An RFA on this topic released in FY 88 should generate fundable applications in FY 88 and FY 89. Similarly, a coordinated RFP on this topic will provide funds for contracts to develop methodology and devices to prevent childhood injury.

The Human Communications portion of the Branch portfolio has shown a consistent growth since our last report to Council. This increase in the past two fiscal years is due in large part to the funding of three large program projects submitted in response to an RFA on sub-typing of dyslexia. The learning and social and affective development programs combined have remained stable (33%) over the past three fiscal years. Program expansion is anticipated in the areas of cognition and social and affective development. This growth will be stimulated by RFAs planned for FY 88 and FY 89. The Developmental Behavioral Biology program has shown a stable pattern of funding over the past three fiscal years. The Branch plans to stimulate the submission of additional applications in connection with a program announcement on this topic to be issued in late FY 88.

An important question concerns the buying power of the Branch budget over successive fiscal years since analysis began in 1978. While there has been a relative increase in the past two fiscal years in constant dollar amount compared with FY 81-85, the Branch budget is not significantly different from what it was in FY 79-80. Said in another way, the research dollar in FY 87 is worth approximately half of what it was ten years ago. The relationship of constant dollars to current dollars is shown graphed in Figure 5. The figure demonstrates that the first increase in constant dollar terms since FY 79 occurred in the just completed fiscal year.

Another important question concerns the relationships between the number of applications reviewed, approved and ultimately funded by the Branch. The data shown in Figure 6 reveal three salient points. First, the total

number of applications being reviewed for the Branch has markedly declined in the last two fiscal years. This drop is paralleled by the number of applications being approved. Second, there is an increase in the proportion of total applications approved relative to those reviewed. Third, the absolute number of grants funded in FY 85 increased dramatically and since then has remained asymptotic. These last two findings may reflect the change from a raw score to percentile cutoff for determining funding.

A question related to the findings just presented is how do HLB applications fare in different study sections? The data in Figure 7 reveal that most of the increase in funded applications from investigator initiated applications is due to the HUD-1 Initial Review Group (IRG). The data also show that HLB applications fare poorly in the Behavioral Medicine, Biopsychology and Sensory Disorders and Language Study Sections. These findings are of great importance for our programs in Behavioral Pediatrics, Developmental Behavioral Biology and Dyslexia respectively . These study sections, it should be pointed out, review for a number of NIH Institutes. The HUD-1 study section reviews only NICHD (HLB) applications. This fact helps account, in part, for the different rates of funding observed.

## PROGRAM HIGHLIGHTS

Since our last report in January 1985, the Branch has grown in overall size and evidences the emergence of well defined themes. These are driven by both investigator initiated research and the skillful management provided by the Branch's health scientist administrators (HSA). These individuals have identified research issues of high relevance to the Institute's mission. Through the use of workshops, conferences and Requests for Applications (RFAs) they have shaped aspects of the Branch program for which they have responsibility. Highlights of progress made are summarized below for each program element by the responsible HSA.

An overarching theme for the Branch is that of interdisciplinary research. The combination of biological and behavioral approaches for gaining a deep understanding of development is central to the goals established for each element of the Branch program.

The Behavioral Pediatrics program, under the guidance of Dr. Peter Scheidt, has been developing a grant portfolio that focuses upon unintentional injury in children. The topic will continue to be a dominant theme for the Branch in connection with the five year research plan prepared at the request of Congress on this topic.

The Developmental Behavioral Biology and the Learning program elements are overseen by Dr. Norman Krasnegor. Two strong themes are evident in the work supported. Research on organization of brain regions by androgens during development has revealed new information on such mechanisms and how they mediate species specific, social and sexually dimorphic behavior in birds. Work on perinatal development has examined the capacity for

learning in fetal rats and pups on the first day of life. Information gained from research on neonatal rats had led to studies of learning in the newborn human.

Cognitive, Social and Emotional Development research is the responsibility of Dr. Sarah Friedman. These programs reflect the interests of developmental psychologists concerning the ontogeny of different aspects of development from infancy through childhood. A particular emphasis area for future planning will be social and affective development in children, which are two domains where additional work has to be undertaken. Planned workshops and RFAs by Dr. Friedman will stimulate the submission of applications to help fill the knowledge gaps that have been identified.

Communication research is under the direction of Dr. David Gray. He has utilized the RFA mechanism to develop a series of program projects (P01) for ascertaining whether sub-types of dyslexia exist. This theme is a significant focus for the Branch that addresses a major learning disability that has public health relevance.

## BEHAVIORAL PEDIATRICS

Research in behavioral pediatrics focuses on applying principles of human learning and development to health and illness behaviors of infants, children and adolescents. When necessary, adults are also studied to gain an understanding of behavioral mechanisms which are instrumental in promotion of child health and the prevention of disease. The goals of this program element are: 1) to link the basic findings in behavioral development with clinical concerns associated with practice of pediatric medicine; 2) to determine how children learn about health and react to illness; 3) to examine the developing behaviors which promote health and well-being across the pediatric age span; 4) to understand the development and antecedents of health-damaging behavior; and 5) to examine how these factors contribute to the etiology and onset of disease and impact upon human health.

### Perinatal Behavior

The newborn infant was once considered incapable of learning and discriminating. Recent advances in the field of infant behavior and development have revealed that the capabilities of neonates have been seriously underestimated and have opened new avenues for understanding and examining the behavior and development of newborn infants. Included in this category is research related to the practice of pediatrics in the perinatal period, normative neonatal development and behavioral effects of environmental exposures.

A Branch supported researcher is investigating the assumption that neonates do not feel pain. Newborn infants undergoing invasive medical procedures in an intensive care unit are randomized to receive lidocaine or no anesthesia as is currently common practice. Preliminary results suggest that local anesthesia attenuates fluctuations in physiological measures of

cardiorespiratory function in sick infants undergoing potentially painful procedures. Thus far no adverse effects of lidocaine have been observed.

Another study is characterizing the newborn infant's behavioral and adrenocortical responses to stressors by examining neonatal behavioral assessment ratings along with saliva and plasma cortisol levels. In this study a significantly lower level of plasma cortisol was found in infants receiving lidocaine for circumcision. Differences in the level of cortisol elevation were related to the level of stress; birth and circumcision were the highest, whereas examinations and heel sticks were lower but still elevated.

Studies are also under way to examine behavioral development of the neonate using biobehavioral methods to assess aspects of normal development. These studies have important implications for early assessment and diagnosis of deficits. One Branch supported investigator is studying maternal voice preference in neonates. With accurate assessments of changes in infant heart rate, heart rate variability, vagal tone, respiration, and sucking, the investigators have been able to measure differences in favor of mother's voice and to document auditory discrimination. These preliminary results demonstrate a learning capability previously unrecognized in newborns and provide evidence for discrimination and preference for the maternal voice.

Behavioral Development in Relation to Medical Conditions

Practitioners and researchers have long been concerned with the impact of various illnesses and conditions on child development. Study of the effects of conditions such as prematurity and central nervous system infections on neurobehavioral development offer opportunity to provide guidance for medical practice as well as improve understanding of the processes of behavioral development. One Branch supported investigator is analyzing cognitive functions and assessments specifically targeted at identifying infants at risk for developmental disability early in infancy. By systematically investigating information processing capacities, habituation, recognition memory, novelty preference, and cross-modal transfer, the foundations are being laid for early assessments and interventions with high risk infants. Another study is examining the effect of H. influenzae meningitis on neuropsychological and behavioral functioning in a population of school aged children. Preliminary results indicate that the morbidity associated with this form of meningitis is not as serious as previously suspected and is associated with neurological sequelae consequent to the episode and other identifiable medical factors. A Branch supported longitudinal follow-up study of infants of diabetic mothers reveals study infants to be similar to infants of non-diabetic mothers with regard to growth, behavior, and development at 24 months; however, the diabetic mothers were less responsive and seemed to experience less gratification with their babies. These findings suggest that diabetic mothers who experience good control of their diabetes during pregnancy can achieve outcome just as favorable as non-diabetic mothers. However, intervention designed to support the mother and to direct her attention to her baby's behavior may be helpful.

## Illness Behavior

One of the most critical behavioral issues that relates to illness, particularly in young children, involves the role of the parents in carrying out medical regimens prescribed for their children. One Branch supported researcher is investigating a strategy using educational material directed at pediatricians to enhance maternal adherence to medical recommendations for children's health care. Pediatrician participants received either a tutorial with printed material or printed material alone to enhance compliance related activities by the pediatricians and a higher rate of measured compliance by their patients. This work demonstrated that patient compliance can be enhanced by strategies aimed at the provider.
Also of interest is a study that focuses upon illness-related behaviors that occur when a child is hospitalized. A Branch supported researcher is collecting data to determine whether hospitalization stress varies as a function of coping styles. Children scheduled for minor surgery were characterized by a scale as a "sensitizer" (seeks information and actively copes) or "repressor" (avoids information). Behavioral observations of coping and physiological measurements were collected to assess how children of different styles coped with invasive and traumatic procedures. The results suggest that although more anxiety was expressed by the repressor children and their mothers, the sensitizer children who experienced shorter duration of intensive care were more active, inquisitive and distressed during invasive procedures. These results imply that the sensitizer group of children have an apparent advantage in coping with hospital stress.

## Risk Taking Behavior

The consequences of risk taking behavior comprise the major source of mortality and morbidity in childhood and especially adolescence; and research directed at understanding and modifying risk taking behavior is a major focus of the Branch.

Research on one such behavior, teenage smoking, suggests that psychological variables must be factored into any treatment program designed to help adolescents avoid or quit smoking. In a cohort sequential investigation of adolescent cigarette smoking, one researcher is following over 4,000 adolescent subjects with a goal of predicting adolescent smoking initiation from several categories of social psychological factors. This study has determined that through early and mid-adolescence, parent influence remained undiminished with regard to smoking even though peer influences increased over the period. This suggests that proximal family influences (such as modeling tobacco use behavior) were important for tobacco use; however, distal family influences (level of supportiveness, degree of control) were relatively poor predictors of tobacco use. Further analyses of this data should form a comprehensive picture of smoking behavior and offer important information for the design of antismoking campaigns.

Analysis is under way with another study using measures of perceived peer pressure, attitude change and perceived vulnerability to identify pathways to peer influence upon cigarette smoking. Preliminary analysis suggests that adolescents' perceptions of how much their friends smoke had

significant relationship to both the quantity of smoking and the self perception as a smoker.

The Branch is also supporting a randomized case/control study to test whether cotinine-assisted intervention can influence pregnant women who smoke to reduce smoking. Second trimester pregnant women who enroll in a pregnancy screening program and who smoke are randomized to intervention and non-intervention groups. The intervention subjects are provided the serum cotinine result, an interpretive report, and a smoking abatement booklet. For 700 of the target 2500 projected participants, mean birth weight for infants born to the intervention group is 48g higher than for the control group. Continuation of this trend would signify an effective intervention to reduce smoking during pregnancy.

Childhood Injury

As the major cause of mortality after the first year of life, prevention of childhood injuries is of high priority to the Institute and the Branch. Accordingly, the Human Learning and Behavior Branch issued a Request for Applications in 1985 "to clarify the major behavioral and environmental variables responsible for specific kinds of childhood injuries." Although a total of 46 applications were reviewed, the initial review group found that the scientific quality of these applications as a group was disappointing and unfortunately the policies for determining scores for special review groups placed all applications outside the range for funding. Subsequently, one proposal focusing on maternal-infant interaction with regard to home hazards was raised to pay and is now under way. To address these problems the Human Learning and Behavior Branch held a workshop on Approaches to Research in Prevention of Childhood Injury in September 1986. The goals were to stimulate interest in research in this area, to identify approaches for research in childhood injury and to identify research methodology needed for the field. Workshop participants included a small group of researchers and practitioners in the area of childhood injury control and behavioral scientists who have conducted research in this area. They identified a series of questions as lines of investigations within a behavioral orientation that are considered likely to result in significant advances toward the control of childhood injuries. In addition, the participants identified methodologies which need to be developed in order to investigate many of the questions facing the field of childhood injury research. To disseminate this information and to provide stimulation and guidance for potential investigators in the area of childhood injury research, the proceedings of the workshop have been submitted for publication in the pediatric literature.

In February of 1987, the Institute submitted to Congress an HLB Branch developed initiative on research toward prevention of childhood injuries. This five year plan is a multifaceted and staged attack on the problem of childhood injuries. First, to develop a better understanding of the behavioral mechanisms and causation of injuries to children, an RFA on the behavioral mechanisms and causes of childhood injuries was published in November 1987. Secondly, a series of contracts aimed at developing specific methodologies identified in the workshop which are needed for

research in childhood injury is planned for fiscal year 1988. Third, a second RFA aimed at application of newly developed methods to develop and evaluate intervention strategies is planned for 1990 and 1991. Finally, as new methodologies and interventions require validation and evaluation, multicenter networks are planned for the latter half of the initiative.

In addition to the above Branch initiative in childhood injury, the staff actively encourages and supports investigator initiated proposals in this area. Currently five projects with a total direct cost of $1,129,683 comprise this categorical portfolio. All but one have been funded by designating discretionary funds for this high priority area.

The first study aims to determine the accuracy of parental information regarding home hazards in relation to perceived purposes of the observation, to assess the relationship between home hazards and children's injuries, and to analyze the interaction of parents and children in the presence of contrived hazards. Preliminary results revealed that when their mothers were distracted, children with a history of injury had a higher level of hazard contact, disruptive behavior, and activity change than children without prior injury. Instead of prompting, reinforcing, or instructing, mothers of children who have been injured were more likely to sit passively or interact only to stop a behavior. These results represent a first step to describe objectively how parents and children interact with home hazards.

The other four studies are just under way this year. One study aims to create a model of the physical and social systems related to childrens' home safety and how they relate to one another. This approach uses detailed mapping of data gathered through interviews and tours of the home made at eight week intervals. The research is designed to yield a detailed description of the functioning of the entire set of factors existing at any one time within a family which help maintain a child's safety at home. This should reveal the range and types of accident prevention strategies used by parents and how they are combined and actually used.

Another project capitalizes on a long standing and highly productive longitudinal study of twins. In this project three cohorts of children will be studied to investigate the developmental relations between children's injury liability and a multifaceted array of behavioral measures including developmental milestones, cognitive skills, temperament, parental background, parental temperament, parental stress adjustment, home environment and others. Furthermore, the co-twin control method will furnish a unique opportunity to examine subtle conditions associated with one twin being injured more than the other.

Defining the role of perceptions of risk in shaping injury prevention strategies is the aim of another recently supported project. This investigator will collect data from 1200 parents over one year to test the causal linkages between perceptions, safety practices and reported injuries. Through such research cognitive models can be developed to predict human behaviors related to the occurrence of injuries in children.

Another Branch supported investigator aims to identify the combinations of variables that best explain the risk of childhood poisoning. This case-control study of children under 4 years of age will examine differences on various risk factors of interest and the relative contribution of socio-demographic characteristics, predisposing factors, life events and situations, behavioral problems, and health beliefs to risk of childhood poisoning.

In summary, support for research in behavioral pediatrics is of high priority for the Branch. Although this area comprises a relatively small portion of the Branch projects and expenditures, substantial increase in this area is expected because of the increasing recognition of the importance of behavior in relation to health outcomes.

DEVELOPMENTAL BEHAVIORAL BIOLOGY

The Branch supports some fifty-five grants that focus upon the biological basis of behavioral development. These comprise approximately 25% of the Branch portfolio. Included in this aspect of the program are studies of brain/behavior relationships; the biochemical, physiological and hormonal bases of behavior; sensory motor processes; and comparative animal behavior. More specifically, the Branch solicits and funds research in six topical areas: (a) developmental behavioral neurobiology; (b) developmental behavioral genetics; (c) developmental behavioral endocrinology; (d) sensory and psychomotor development (e) developmental behavioral toxicology.

Funding by the Branch of research on brain/behavior relationships that are influenced by hormonal secretions has played a significant role in gaining an understanding of social, maternal, species specific and sexually dimorphic behavior. A number of studies supported by the Branch are investigating how hormones help organize the central nervous system and thereby determine social behavior. The work being supported is laying the groundwork for elucidating how androgens and estrogens interact to organize brain regions responsible for activating vertebrate social behavior. A number of studies supported employ birds as the subjects of interest. The use of avian species is quite appropriate because their social interaction patterns are so well studied. Therefore, experimental manipulation of hormones can be well related to social interaction patterns. For example, one of our Branch supported investigators is examining the hypothesis that estrogen secretion in the male Zebra-finch increases the number of androgen receptors in areas of the brain that are associated with sexual function and species specific song. Her work also includes studies of the role played by dihydrotestosterone (DHT) and estradiol on cholinergic and cholinoceptive neurones that have been implicated as being necessary for the control of steroid sensitive vocalizations in this bird species.

Another of our grantees has continued his studies of learning in birds. He is particularly interested in determining how budgerigars (Australian parrot) learn their species specific song. He employs sophisticated psychophysical scaling procedures to determine what the budgerigar

perceives about the acoustic stimuli in its native song that allows it to employ that information during mating and other essential social behaviors. His results demonstrate that this species of bird learns its vocalizations. Further, he discovered that budgerigars have natural perceptual categories for their vocal signals.

Avian models are also useful for elucidating the way that hormones help organize areas of the brain involved in other species specific behavior. For example, research on mechanisms by which estrogen secretion increases androgen target cell numbers in areas of the brain thought necessary to mediate song in males and androgenized females is under study. The investigator is also attempting to identify areas of the finch's brain where estrogen acts during development to masculinize song control loci. Results have shown that masculinization may occur by: (a) selective retention of certain cells during a time when others die off or (b) neuron proliferation. In this latter process, cells in certain song control nuclei of the brain are actually added during development.

In other studies, still under way, the seasonal change in male canary song is used as a marker to study the role of androgen levels in the retention and disappearance of species call. The investigator uses implanted androgen to maintain high levels of testosterone in his subjects throughout a season. By controlling androgen level he can correlate hormone level with the size of brain areas putatively involved in the mediation of song and the song itself at the start and end of the experiments. The investigator is also studying how implanted testosterone influences brain lateralization of song organization in canaries which have the crucial nuclei ablated on the left side of their brain. Such work should verify whether androgen plays a necessary role in the organization of song.

Taken together, these studies are contributing significantly to our knowledge of the role played by hormones in organizing the neuroanatomical basis for sexually dimorphic, species specific vocalizations and social patterns of interaction.

Another area of research supported by the Branch is studies seeking to understand the relationships between hormones and the central nervous system in the initiation of maternal behavior. A recent conference sponsored by the Branch (Biological and Behavioral Aspects of Parenting in Mammals) was held in September 1987 to explore this and other relationships of hormones, brain and behavior. Several of our grantees have been investigating animal models that may help elucidate hormonal mechanisms which trigger maternal behavior upon parturition. One of our grantees, for example, is studying the role of prolactin in the initiation of maternal behavior. His studies focus upon the sites that prolactin acts in the brain during various reproductive states. Other of his studies focus upon the behavioral effects of prolactin when it is directly administered into the lateral ventricles and other brain loci of female rats which have not given birth. Included in his research program are experiments to examine the specificity of prolactin's probable site of action by treating rats centrally with hormones in the prolactin-like family of hormones such as growth hormone and placental lactogen. Recent findings from his laboratory

indicate that progesterone and ectopic graft secretions stimulated a rapid onset of maternal behavior in both hypophysectomized and non-hypophysectomized female rats. Exposures to progesterone or the grafts alone were without effects.

Such work exemplifies another aspect of behavior in which hormones exert a controlling influence. This research is part of a genre which will significantly enhance our understanding of how brain interactions with hormones mediate parenting behaviors in mammals.

Gonadal hormones have also been implicated as having an organizing function which underpins brain lateralization associated with sexually dimorphic behavior observed in boys and girls. One of our grantees, for example, is interested in the effects of androgens and estrogens on cognitive and social development of male and female children. Her experiments are designed to elucidate the bases for differences in rough and tumble play, toy preference, verbal and spatial capacity, mathematical and reasoning abilities, cerebral hemispheric specialization for verbal processing and personality factors observed in boys and girls. She is attempting to discover the particular hormones responsible for masculine-typical development of the behaviors enumerated above. Her subjects include male and female children who have been exposed to excess endrogen due to congenital adrenal hyperplasia (CAH); girls exposed to excess androgen prenatally because their mothers were prescribed diethylstilbestrol (DES) during pregnancy; and genetic males who are phenotypically female due to androgen insensitivity (AI). This research should shed new light on how hormones influence behavioral development and provide new information on the relevance of animal models for understanding hormone-brain-behavior relationships in human development.

In summary, Branch supported investigators are employing animal models to study the role(s) of hormones in brain organization believed to be necessary for the expression or mediation of social, species specific, parental and sexually dimorphic behaviors observed during development.

LEARNING

The Branch portfolio contains a number of grants which are designed to gain a basic understanding of learning mechanisms within both comparative and developmental frameworks.

A new and exciting trend in biological science is the analysis of mechanisms of interest at the molecular level. Work at this level of analysis for learning is in its formative stages of development. The Branch supports examples of this type of research. One such project involves the exploration of mechanisms that may subsume associative conditioning in the marine mollusk, Hermissenda. Results from the work to date have demonstrated that a conditioned stimulus (CS) paired with the direct application of serotonin (5-HT) can mimic conditioning in this animal. The studies have also shown that long-term memory associated with conditioning is dependent upon protein synthesis. The work is important

because it demonstrates a way to employ biological tools for analyzing the bases for simple forms of learning and memory.

Another trend that is apparent in our grant portfolio is research on learning as early in life as this form of behavior can be measured. By studying learning processes as they emerge our Branch supported researchers have a better chance of characterizing the necessary mechanisms that underpin these behavioral processes. Thus a number of our researchers are studying learning during the perinatal period of development.

One of our grantees, for example, has continued his research on behavioral development in the rat fetus. His work has demonstrated that learning (classical conditioning) can be achieved in this organism as early as day 17 of gestation and is consolidated by day 19 of gestation. Such learning by the rat fetus is retained beyond the second week of post-natal life. The research has also demonstrated that there is a systematic ontogeny to the organization of rat fetal movement. This research has opened the way for the systematic study of learning in the rat fetus and portends whole new methodological breakthroughs for conducting behavioral toxicology research.

Closely allied to the aforementioned studies is work being conducted on early learning in the neonatal rat pup. One of our researchers continues his studies of motivation in one day old rat pups. His work to date has demonstrated that behavioral activation is not essential for reward or learning. Recent studies by him have shown that lateral preference learning is lost when the commissural projection systems of the rat pup's brain are developed and in place (2nd post-natal week). This investigator has also elucidated specific brain loci that are correlated with motivation. He has employed 2-deoxyglucose autoradiographic methods to map areas of the brain that are necessary for the type of early learning that he is investigating.

One exciting new trend that has been emerging during the past four years is that researchers who have studied learning using animal models have begun to analyze functional learning in the human neonate. One such scientist has focused his work on the learning mechanisms employed by one day old human babies to recognize their care giver. His work supports the conclusion that classical conditioning is a likely mechanism by which babies learn about their mother. Results have revealed that click sounds similar in spectographic properties to those made by nursing mothers can serve as effective conditioned stimuli for head turning and lip puckering in neonates. Such associative learning may help promote mother-infant attachment.

In summary, the Branch program has continued to support learning research at the cutting edge of this field. The work is making contact with molecular biology and is studying mechanisms of learning as they emerge during perinatal development. Most importantly, those who have long worked in animal research are applying their analytic skills to the human neonate to help elucidate the functional significance of learning mechanisms as these occur in natural ecological settings.

## COGNITIVE, SOCIAL AND EMOTIONAL DEVELOPMENT

While the cognitive development, the social development and the emotional development of children are believed to be interdependent, scientific research frequently focuses on these three aspects of development as if they were mostly independent. This tendency to compartmentalize human development for the sake of making theory building and research efforts manageable is reflected in many of the research studies supported by HLB.

This report will include research highlights in the areas of infant cognition, cognitive development in childhood, social development, emotional development and social influences on development. Current research as well as future directions in both basic and applied research will be mentioned.

### Cognitive Development

The HLB Branch supports research on the mental processes of infants and children and on changes in these processes as a result of development, practice and exposure to different favorable or unfavorable experiences. Examples of mental processes include attention, perception, and memory. The cognitive development grants supported by the Branch may be classified as those pertaining to such development in infancy or childhood.

#### Infant Cognition

The Branch supports a substantial number of grants in the area of infant cognition. Most of these deal with the attributes of objects that lead infants to behave toward them as entities and as belonging to a class of other objects. The mechanisms by which infants collect and store information about objects, i.e. attention, sensitivity to similarity and to contrast among displays, the cross modal enrichment that occurs when information arrives through multiple sensory modalities, and knowledge representation are also being investigated by researchers supported by the HLB Branch. The growing interest among cognitive development researchers in (a) the predictions that can be made from cognitive status in infancy to later cognitive status and in (b) social influences on the acquisition of cognitive skills is also reflected in the grant portfolio of the Branch.

One of the investigators in the area of infant cognition completed three studies of the development of infants' ability to use gestalt relations as information for the unity of partly occluded objects. "Gestalt" refers to the German word meaning "pattern" or "form." Gestalt psychologists held that in perception we are aware directly of a configuration or structure which is grasped as a whole and not merely as an assemblage of its parts. The principle of gestalt that was investigated in relation to infants' perception is that of good continuation (that we see contours as following natural lines). The findings revealed that 5-month-old infants are not sensitive to the aspects of good continuation that were examined. Seven-month-old infants, in contrast, are sensitive to one of the aspects examined but not to another. Sensitivity to the other aspect is present at 24 months.

Another investigator conducted four experiments to examine developmental change in 4-, 7-, and 10-month-old infants' perception of correlations among attributes of animal drawings. The results suggested a developmental progression in infants' processing of simple correlational information, ranging from the processing of independent featural information at 4 months, the perception of relations among features of a single pattern at 7 months, to the abstraction of invariant relations from a category at 10 months.

Knowledge about the cognitive function in infancy allows investigators to branch out and ask questions about the predictive validity of measures of infant cognition. For example, one investigator who studies habituation, recognition memory, novelty preference and transfer of information across sensory modalities is now tracing the relations between cognitive capacities of 5 to 6 month old infants and the same infants' performance between 12 and 48 months on the same measures, on measures of language proficiency, on psychometric intelligence and on cognitive measures like play and classification.

The knowledge that is now available about the cognition of young infants is also being used to compare the development of healthy middle class infants with the development of infants who are at risk for optimal psychological development because of medical complications or societal disadvantage. This type of "applied research" actually expands psychologists' understanding of the limits of normal development. When the research combines cognitive measures with measures of physiologic function or brain function, as is the case in some investigations supported by HLB, the understanding of infants' cognitive function as an index of infants' overall health is enhanced considerably.

Cognitive Development in Childhood

In addition to the investigations described above, the HLB supports research exploring the development of cognition beyond infancy. One research question that ties together the infant cognition research and the childhood cognition research is that of concept formation. The term concept formation refers to the abstraction of categories on the basis of exposure to specific exemplars from a given category. One HLB supported investigator studies the acquisition of relational concepts, another studies concept learning under conditions that allow the discovery of predictive relations among characteristics. Concept formation can be subsumed under the more general topic of knowledge acquisition that is a focus of other investigations. For example, one of the HLB grantees asks: When someone points to an object and labels it, how does the child determine that the term refers to the object category as opposed to all the other possible things it could mean? Other HLB supported investigators are asking questions and providing answers about knowledge representation in memory and knowledge use. One investigator finds that the child's representation of narrative discourse can be depicted in terms of a network of events and their causal relations. Another investigator studies the strategies children use when solving math problems. It should be noted that the last two examples relate to children's everyday cognition, the

cognition that children use on a daily basis when they attend school. This interest in children's acquisition, representation and use of information or cognitive skills that serve them well in their daily life is reflected in many of the investigations that are supported by HLB.

A specific example of research in the area of knowledge acquisition comes from the research of an investigator who studied toddlers' use of linguistic contrast to narrow down a word's meaning. Two- through four-year-old children were introduced to a novel color, shape, or texture word by contrasting the new word with a well known word from that domain. They were then tested for their knowledge of the new term. Children learned something about the meaning of a word for each of the semantic domains examined. When the context was compelling, however, children learned even without hearing any linguisitic contrast.

In another study the same investigator examined cases where there was more than one compelling hypothesis for a word's meaning. The researchers found that children had preferred hypotheses; in particular they favored shape and material over color in their hypotheses about a word's meaning. The children readily made use of information from linguistic contrast when it confirmed a preferred hypothesis, but failed to make use of it when it supported a non preferred hypothesis. This bias is provocative and leads to questions about its origins and robustness.

A specific example of research in the area of knowledge representation comes from an HLB supported study aimed at understanding (a) the development of early knowledge about experienced events and (b) young children's retrieval and use of event knowledge. Three and four year olds participated in a "science experiment" event over eight weeks. Children in one group were questioned later on the same day of each event occurrence; children in a second group were questioned one week after each event, before the next event occurrence; children in the third group were questioned after the eighth event occurrence. Preliminary data shows that four year old children report more and need less prompting than three year olds. Children in both age groups report more as a function of experience. Approximately a month after the eighth event session, eight children in each age group were presented with 6 line drawings depicting actions which occurred in the "science experiment" procedure. With the exception of one three year old child, all children were totally accurate in judging the temporal order of the occurrence. Two other groups of children were asked to judge the importance or centrality of events. The task proved significantly more difficult than the temporal ordering task. Agreement within age groups and with adult judgments increased with age. A study of judgments of typicality of events showed that children's judgments were more variable than adults' and that children's judgments correlated more highly with adults' as a function of age.

A specific example of research in the area of knowledge use comes from a study of strategies young elementary school children use when adding numbers. Previous models have depicted children as always solving simple addition problems by using the min strategy. The min strategy involves counting-on from the larger addend; thus on "3+6," a child using the min

strategy would say "6,7,8,9." The min model predicts that the solution time on each problem will be a linear function of the smaller addend. This prediction has proved accurate for both individuals and for groups, in both Europe and North America, in both standard and special education settings. An HLB supported investigator listened to children's verbal reports of which strategies they use. These reports suggested that the min strategy was one of five approaches that children are using. The children indicated that they use the min strategy in only 36% of the trials. Dividing the error and solution time data according to what strategy children said they had used on that trial lent considerable credence to the children's verbal reports. On trials where they said they used the min strategy, the min model was an even better predictor of solution times than in past studies or in the data set as a whole. In contrast, on trials where they reported using one of the other strategies, the min model was not a good predictor of performance.

An area of cognitive development which is relatively unexplored and which HLB Branch would like to stimulate is that of planning. There is no doubt that planning is a central facet of human behavior, yet as a topic of scientific investigation, planning has been very elusive. The reasons for this elusiveness are multiple: planning has many components; its evocation and application are influenced by cognitive, affective and social factors and its content differs widely across domains. In order to encourage research about the development of planning, HLB Branch is in the process of preparing a Request for Applications about this topic. The requested research will integrate knowledge and research methods that are already available to cognitive developmental psychologists. It will draw on knowledge and measuring techniques pertaining to children's representation, selection, monitoring, evaluation, decision making, knowing when to apply knowledge, execution, debugging, learning from past cognitive activity or past action. The requested research will also draw on current thinking about motivational, emotional and social influences on the cognitive abilities of children.

Another area of cognitive development which is unexplored is that of children's knowledge and understanding of humans as sexual beings. The menace of Acquired Immune Deficiency Syndrome (AIDS) has led many to claim that at present, the best immunization against AIDS is education of the public (including pre-adolescents and adolescents) about the disease and about ways in which it can be prevented. Since AIDS is to a large extent a sexually transmitted disease, educators must know what children of different ages know and are capable of understanding about sexuality. An HLB initiated Request for Applications calls for research on this topic as well as on other behavioral topics related to the prevention of AIDS.

Social Development

The HLB Branch is supporting research about the social development of children. It is interested in investigations of social development from early infancy through the toddler age, early childhood and adolescence.

From birth on, the child is a part of a social environment. This entails communication with social others, entering into close interpersonal relations with some of them and learning how to behave in socially acceptable, desirable and captivating ways. Applications about the development of social knowledge and social skills as these pertain to interaction with parents, siblings, peers and others are all of great interest to the HLB. Also of interest are investigations of the intra-individual (e.g. cognitive, emotion related) and inter-individual (e.g. familial, cultural) processes that influence children's social development. At present, investigators supported by HLB study social information processing; the relationship between information processing and the development of social competence and peer relations; the role of family variables (e.g. family interactional processes) in the development of the child's peer relations; qualitative features of sibling relationships and the role of ethnicity in friendship and in social adjustment.

One of the HLB supported investigators studied the development of companionship and intimacy during preadolescence and adolescence. The research participants who were in second, fifth and eighth grades rated the importance and extent of companionship and intimate disclosure experienced in social life in general and in each of 8 types of relationships. Companionship was perceived as a desired social provision at all three grade levels. Family members were found to be important providers of companionship for children in the second and fifth grades, but they became significantly less so at the eighth grade. Same sex peers were important providers across all three grades, and they became increasingly important as children grew older. Opposite sex peers did not become important as companions until the eighth grade. There were no age differences in the global desire for intimacy. Parents were important providers of intimate disclosure for the youngest children, but they were less important among the younger adolescents. Girls were found to seek intimate disclosure in friendship at younger ages than boys.

The topic of intimacy is becoming very important in relation to attempts to influence the course of transmission of the deadly HIV virus. Since a major route of transmission is sexual contact, there is a need to understand the social processes that lead individuals to have one, a few or many sexual partners. The threat of AIDS also leads to the need to continue to study children's and adolescent's social skills, especially as these pertain to resisting pressure placed by a dear friend or by the group that one is affiliated with or would like to belong to.

Children growing up in the United States, especially minority children, are facing the challenge of figuring out their ethnic identity and of learning to establish cross-racial friendships. One investigator supported by HLB has set herself the goal of studying the development of ethnic identity by Hispanic, Black and White American adolescents. Another HLB supported investigator examines the effects of structural and organizational characteristics of schools on the formation of interracial friendships and on change in friendship relations between Black and White fourth through seventh grade students in 48 classrooms in 10 California schools.

The HLB Branch is interested in increasing the number of applications it supports in the area of social development. It is also planning to encourage researchers to focus on the development of standardized measures of social competence in childhood and in adolescence. There is a realization that there is sufficient basic research that should allow investigators to develop such instruments. There is also a realization that the equivalents of I.Q. tests in the social and emotional domains are needed to evaluate the outcome of children who are at medical or societal risk for optimal psychosocial development. A major reason for lack of information about the social and emotional development of these children is the lack of standardized instruments. In the absence of direct measures of social competence, investigators who are interested in the social adaptation of children at risk interview parents and children about the social adjustment of the children. This method of collecting data is used by a group that has a contract with HLB to follow-up the development of school age children who were of very low birthweight.

Emotional Development

Emotions like joy, hope, affection, interest, anger, disgust, surprise, fear, sadness, guilt and shame exist in the repertoire of children and many of these emotions are known to also be present in the repertoire of infants. The scientific study of emotions and of emotional development is only now emerging from an extended period of neglect. This neglect has resulted from the widespread but incorrect belief that emotions were neither regulatory of human behavior, nor measurable with any degree of specificity. Although badly neglected until recently, the study of emotion has entered a period of great resurgence of interest, mediated by important advances in the measurement of emotions in the face, voice, autonomic nervous system, and the brain. In addition, important conceptual advances are taking place in understanding both the nature of emotion elicitation, and the functions of emotional reactions.

While at this time the HLB Branch supports a very small number of grants in the area of emotional development, these grants reflect some of the lines of research that are now being pursued. One investigator studies the relation between facial signs of discrete infants' emotions and the concomitant central nervous system processes. Another investigator concentrates on one of the complex emotions, i.e. empathy. She plans to differentiate various modes of empathy, to study the convergent validity of various measures of empathy and to examine age related changes in it. Another researcher studies what might be considered one cognitive prerequisite of empathy, that is, children's ability to use personal information so as to infer emotional reactions of other people. Another complex emotion that is being studied by an HLB Branch supported investigator is that of helplessness in reaction to failure experiences.

In the study that related facial expression of emotion and EEG responses the subjects were five and ten months old male and female infants. They were presented with a variety of stimulus situations including presentation of different liquid tastes and approach of an unfamiliar person who was expressing either a neutral or smiling facial expression. EEG from left

and right frontal and parietal scalp locations was recorded, while infant facial, gestural and vocal behavior was videotaped. When the infants were expressing the emotions of felt joy, they displayed greater left frontal activation compared with periods during which an "unfelt" smile was present. During expressions of both anger and sadness, the EEG data revealed greater right frontal activation during both of these expressions when they were accompanied by crying compared with a display of these expressions in the absence of crying. For most of these comparisons parietal asymmetry failed to discriminate between the expression conditions.

Another HLB investigator studies children's ability to use person-specific information, indicative of individual differences, to predict and explain the emotional reactions of other people. Children in kindergarten, second grade and fifth grade heard six stories of either the protagonist's behavior or experience in one situation, followed by a second, similar situation. They were asked to infer the protagonist's emotional reaction in the second situation. Other children only heard about the protagonist's behavior or experience in the first situation and were asked to infer what the protagonist thought of the situation. The findings indicate an increase with age in children's ability to infer other people's appraisals from their prior behaviors or experiences, and an increase with age in children's ability to make emotional inferences that reflect their appraisal. Children are better at inferring other people's appraisals of situations than at using that understanding to infer these people's emotional reactions to later, similar events. When inferring other people's appraisals and probable emotional reactions, children are marginally more influenced by information about the people's prior behaviors than by information about their prior experiences.

In summary, the HLB Branch is supporting and is interested in continuing to support investigators who study emotions and emotional development in infancy, in childhood and in adolescence.

Social Influences on Cognitive, Social and Emotional Development

The grant portfolio of HLB reflects the interest of developmental psychologists in the processes by which the culture and the family contribute to the cognitive, the social and the emotional development of children.

Social influences on cognitive development

There is ample information in the research literature showing that the family and the culture in which the child grows have an effect on his or her cognitive development. These data as well as the interest in developing intervention programs, have led scientists to ask questions as to how members of the family and how institutions like schools affect psychological processes involved in knowledge acquisition, its representation in memory and its use in problem solving situations.

One recently supported project will investigate the different types of parental interaction strategies and the factors that contribute to variation in those strategies. The same project will assess the contingency of mother and child behaviors and the extent to which parental behaviors help four-and-a-half year old children become competent. In another ongoing investigation infants and mothers are assessed at multiple points to permit causal analyses of factors influencing cognitive development between one and four years of age.

In the coming year, HLB will support a workshop on the socialization of cognition. The purpose of the workshop is to discuss questions regarding the malleability of different cognitive skills, the different socializers of cognition, the different methods by which cognition is socialized and the everyday situations under which aspects of cognition are socialized. Methods by which the above questions can be studied will also be considered.

Social influences on social and on emotional development

Evidence from anthropological research indicates that social and emotional related behaviors of individuals have both universal and culture specific aspects. The many culture specific aspects suggest that social and emotional development are shaped by social factors. Developmental psychologists conducting research in the areas of social and emotional development are asking questions such as who are the socializers, what are the circumstances under which socialization occurs and what are the specific interactional processes by which it occurs. The HLB Branch supports a small number of investigations pertaining to the social influences that shape social and emotional development. These investigations focus on family variables (e.g. working parents, step families, quality of marriage) and maternal variables (responsiveness of the mother) as possible shapers of social and emotional adjustment.

One HLB Branch supported grantee investigates the relationship between family process, family organization and adult/child psychological outcome in stepfather families and non-divorced intact families. The study revealed that dysfunctional family processes, more life stress, less cohesion, and less adaptability correlated with more behavior problems in children. Children's externalizing problems were associated with being in a step family, with low affective involvement, and with more overall dysfunctional family process.

The HLB Branch is now planning a workshop aimed at mapping out what is known and what new knowledge needs to be acquired about (a) aspects of emotional development that are influenced by the culture and the family in which a child is reared. An example of such an aspect is the acquisition of complex emotions such as pride, jealousy, hope and shame; (b) the processes by which the culture and the family influence or shape the perception and expression of intrapersonal and interpersonal emotions. Examples of such processes are imitation, reinforcement and discussion.

Two Requests for Applications, one to be awarded in the beginning of 1988 and the other at the end of 1988 or in 1989 deal with the topic of social influences on child development. The first RFA is titled "Minority families and children: Behavioral and societal variables affecting children's development." Fifty two applications were submitted. The second RFA will be entitled "Effects of non-parental day care on child development." These two staff initiatives reflect the conviction of the NICHD program staff and of the scientific community that there is a need to study the intricate ways by which the social environment influences specific aspects of child development.

Conclusion

The highlights concerning current HLB supported research and the future directions planned by its program staff show that the development of children as cognitive, social and emotional beings is an important research focus for this Branch. The highlights also underscore the fact that the basic research that is supported by the Branch leads to knowledge and to the development of research methods that make it possible to address research questions related to public health. Knowledge about the development of low birthweight infants and about other children exposed to medical risks; knowledge about the development of children exposed to environmental risks (e.g. pollution, poverty, stress) and answers to questions about the development of children of employed mothers--all these could not be possible in the absence of basic research about children's psychological development. Likewise, attempts to arrest the spread of HIV infection through behavioral means rely on methods and knowledge generated by researchers in the area of psychological development.

COMMUNICATIONS

The Branch supports 48 grants that focus upon communication research. These comprise approximately 36% of the Branch funds. Included in this aspect of the program are studies of genetic, neurological, maturational, and environmental factors influencing the development of speaking, listening, writing, and reading. The study of symbol acquisition by great apes, modality specific aspects of language development, the development of speech reception and production, and the complex processes involved in the acquisition of reading have been the focus of the HLB Branch funded research for many years. During the past three years, increased emphasis has been placed on discovering biological bases of human communication, early identification of abnormal language development, defining and categorizing poor readers, and linking the results of basic research to improving intervention programs.

Language - Comparative Animal Studies

The search for a link between communicative behaviors and their biological foundations has led Branch supported investigators to examine the capacity of the great apes to learn and to use abstract symbols to represent objects, respond to human speech and to emit sounds unique to having

learned symbols. For example, the ability of a pygmy chimp, Kanzi, to detect speech sounds as representations of objects is being studied as a method to examine the ability of a lower organism to co-relate abstract sound and visual symbols, a process which may be fundamental to the human acquisition of reading. In one study Kanzi pressed a visually depicted symbol on his symbol board to produce the synthesized speech equivalent to its English equivalent. After training he was tested on his ability to match the synthesized speech to his symbol board which contained 65 symbols. He scored 88% correct. This indicates that he is able to correctly identify visual symbols and sound signals for equivalent objects.

The orangutan, common chimpanzee, and the pygmy chimpanzee have all demonstrated the ability to learn a large number of symbols and to use them, albeit not with a inherent syntax, to communicate needs both to the researchers and to each other. The development of symbol acquisition is being studied by observing a pygmy chimpanzee (Pan paniscus), Mulika, who is being reared with Kanzi, who had previously learned to use symbols. She exhibited the same symbol acquisition pattern as Kanzi but at a younger age. Her initial use of the symbol "milk" was as a generic symbol for all food. Once she learned the symbols for other foods in her diet, the overgeneralization usage dropped out of her repertoire much as it does in human infants who are acquiring and using language. In another study of language-like processes, researchers found that chimpanzees need to be taught how to "listen" to the presentation of symbols in order to respond to the request of the "speaker."

As a vehicle for studying the origins of language, these studies demonstrate that great apes have the ability to learn a number of component skills which are necessary but not sufficient for the use of language. The pragmatic aspects of this research have been illustrated by studies where the procedures used to train apes, communication through symbols, have been effectively used to teach severely developmentally disabled individuals how to communicate their needs to their parents, teachers, and care providers.

Language Development - Non-speech Based

A Branch supported researcher is examining the visual-gestural sign languages used by deaf individuals to discover underlying fundamental properties of human language. The sentence structures of sign languages are represented by temporal and spatial parameters of hand and arm movement which can be reconstructed three dimensionally by computerized graphic displays. As listeners delay the assignment of meaning to words of a sentence until the sentence is complete, signers use only partial information about a sign as it unfolds in time to access a lexical item. Using the American and Chinese Sign Languages to search for basic linguistic similarities, one investigator found that they share similar basic principles of grammatical patterning. Inflection is given by superimposing elements such as movement contours and doubling hands on a sign stem. Inflection and stem are produced simultaneously rather than sequentially in both languages. A study of left hemisphere brain damaged deaf signers found evidence for hemispheric localization for reception of moving signs but not static signs. Furthermore, right hemisphere damaged

deaf signers were unable to process non-language spatial relationships. Thus, hemispheric localization of language is not limited to speech and hearing based languages. The specialized processing of the left hemisphere seems to be a general linguistic function. These studies show that sign and sound based languages share similar grammatical and biological properties.

Language Development - Speech Perception

One of the first areas of investigation funded by the HLB Branch and one which continues to play a major role in improving the understanding of the development of language is research directed towards discovering when the developing infant perceives sound as meaningful communication and what the ontogeny of the production is. The findings of several studies of adults showed that meaningful auditory stimuli are perceived as discrete units rather than a continuous distribution of sound. These building blocks of oral language (phonemes) have been found to be perceived as distinctive sound categories by infants in the same manner as adult listeners. A current study on this topic compares adult and infant ability on the detection of consonants in the context of /s/ followed by a vocalic segment when there is little or no silence between the two acoustic segments. Earlier studies had shown that in adults sufficient silences between the two acoustic segments transitions are heard in the form of stop consonants. For example, with a period of silence between sounds, the adult listener will hear the syllables /sta/ versus /spa/ but in the absence of silence both sounds will be heard as /sa/. The researcher found that young infants could discriminate the transitions equally well with a very brief silence. Thus, the perceptual system of infants for the reception of the speech signal is influenced by temporal variables in a manner similar to that of adults. This finding suggests that some aspects of speech perception are controlled to a large extent by the inherited biology of the speech receptor organs and speech processing centers of the central nervous system.

Language Development - Speech Production

In a six year study of the development of infant vocalization, a Branch supported investigator found that vocal development is closely tied both to the maturation of the central nervous system and to vocal feedback from self and adults. This investigator found that early landmarks of vocal development, cooing and reduplicated babbling, are separated by a period of rapid expansion of vocal skills when control over phonation is first demonstrated. This expansion period varies not only in the types of sounds produced, but also in the order of their appearance. For example, friction noises and trills may appear in one infant first while shrieks come at a later time; for a second infant these sound types might appear in reverse order. This variability in speech production parallels maturational differences in the limbic system. That auditory feedback plays an important role in the expansion phase of infant vocal development is illustrated by the finding that deaf children do not elaborate on their speech sounds until they are provided with amplification and that hearing impaired infants demonstrate a six month delay in the onset of reduplicated

babbling even when provided hearing aids. This series of studies illustrates that the ability to produce meaningful speech depends upon genetic, maturational, and experiential factors.

Language Development - Transition from Sound to Visual

One of the most important developments in the ontogenesis of language is the transition from the total reliance on spoken language to the ability to use visual abstract symbols. The relationship between language development by eye (visual) and by ear (auditory) has been the subject of numerous NICHD funded research projects. Studies on the normal development of the transition from oral to written language have demonstrated that in order to read one must be able to represent and access the sounds of a word, break words into their component parts by sound, develop and retain a large and quickly retrievable vocabulary, make rapid discriminations based upon the syntax of the sentence, and adjust quickly to contextual cues for comprehending the meaning of the text. Deficiencies in any of these processes may result in poor reading performance.

Reading - Phonological Basis

Over the past twenty years, studies funded by the Branch have provided experimental evidence supporting this theoretical explanation of the transition from oral to written language. One study showed that children who are poor readers can name letters of words, even in the correct order, but have difficulty correctly saying the word. Another study found that when poor and normal readers were asked to learn complex symbols which had no meaning or sound associates, they performed poorly. Poor readers have great difficulty segmenting printed and spoken words into individual components (phonemes). Students were tested to measure their proficiency in reading nonsense words and unfamiliar words. Less skilled readers performed poorly, suggesting that poor readers have great difficulty decoding the written word into a sound code for processing. Additional evidence supporting this explanation of the development of reading is that children who exhibit an average ability to break words and syllables into sound units develop normal reading skills. Preschool children who are good at rhyming words or parts of words are found to be good readers when examined in grade school. Comparisons of second grade poor readers with sixth grade poor readers showed that the inability to use sound decoding skills to read new words remained deficient even when other reading related skills improved. While these studies suggest that the phonological skills are consistently found to be deficient in poor readers, a recent study found that children who were instructed in identifying phonemes early in grade school showed significant improvement by sixth grade. This series of findings illustrates that phonological skills are important in acquiring proficiency in the written language and that some phonological skills may be improved through practice.

Language Development - Reading, Processing Abilities

In addition to phonological abilities, reading requires rapid storing of information in short term memory and retrieving information from long term

storage. Studies comparing dyslexic and normal reader skills in recalling words immediately after hearing them presented, find that dyslexics are less able to use short term memory for recalling the verbally presented words. Tests of retrieval of words, objects, colors, and numbers were all performed slower and with more errors by dyslexics. This implies that the retrieval processes of dyslexics are impaired. In an association and rule-learning study of storage and retrieval of visual-verbal and visual-visual associations, the dyslexic children performed poorly when compared to normal readers only on the association task requiring storage and retrieval processes of verbal to visual associations. These findings indicate that dyslexics have a specific deficit in coding, storing, and retrieving symbols with sound equivalents rather than a general decrement in ability to discriminate, analyze, place information into storage, or retrieve information from memory.

Language Development - Reading Comprehension

While making the transition from oral to written language may be necessary for reading, understanding what is coded in the written message requires using other aspects of linguistics. Changing a single word, using varying syntax, and altering larger contextual units such as sentences and paragraphs have been used to study changes in comprehension. For example, a common method for analyzing reading comprehension has been to measure when during the course of reading an individual assigns meaning to words. This task has been difficult because researchers have had to rely upon the subject's verbal or manual report. However, both output functions interrupt the flow of reading. Branch supported investigators are studying the development of comprehension by measuring changes in eye movements made during reading, recording electrophysiological brain wave changes that occur during reading test sentences, and testing performance changes on a newly developed reading comprehension test.

Eye movement measures are being studied not to investigate a causal role in the acquisition of basic skills, but as a way of characterizing changes in reading comprehension and to study cognitive processes involved in reading. As people read, they make a series of discrete eye movements (saccades) and pauses (fixations) which can be tracked using sophisticated computerized equipment. One Branch supported investigator compared the eye movements of young children who were learning to read with the eye movements of adult proficient readers. His studies show that by first grade the attentional and oculomotor systems are fully developed in their ability to target a word in the text for attention and to move the eyes to that word. In contrast to children, adult good readers tend to spend less time, have fewer fixations, and have a reduced number of gazes on words with which they are familiar. Adults spend proportionally more time when they encounter new or unfamiliar words as measured by increasing fixations and gazer frequency. As children advance in their reading skills, the fixation times and the probability of refixating on a word show similar curves but with different parameters. These findings may indicate that as basic oral to written transition skills are mastered, more time is devoted to the comprehension of the words being read. As the data base of this study expands and as new analyses of the data are made, the results will allow

scientists to describe normal and abnormal strategies used by children during the acquisition of reading. These patterns of development may provide a basis for examining the reading behavior of developing children classified at-risk for dyslexia and suggest strategies for correcting their problems.

Recently, electrophysiological recordings of brain activity have been used to examine the effects of altering the linguistic aspects of written materials on the time taken to comprehend the meaning of words, phrases and sentences. A negative electrical potential described as the N400 wave has been found to be sensitive to changes in word meaning. One study found that the N400 wave is delayed by changing the subject's expectation of the meaning of the text by inserting into a sentence a word that does not fit the meaning of the sentence (semantic priming). Another study found that reading comprehension was disrupted when the normal sentence structure was altered. Certain types of sentences, a wh- question sentence for example, require a reader to look elsewhere in the sentence for clarifying the meaning of the sentence. By altering the position of the word that makes the sentence meaningful or by changing the word from meaningful to contextually ambiguous, the investigator can examine when during the course of reading the sentence, the reader makes the decision as to the meaning of the sentence. In a study using a wh- question sentence with an ambiguous word where one word at a time was presented to the subject, one investigator found that N400 wave for the verb at the end of the sentence was larger than when the sentence contained no unambiguous words. This finding indicates that normal readers use the syntax of the sentence as a cue to delay decisions on the meaning of sentences.

Reading - Test of Comprehension Levels

The development of reliable and valid assessment tools to normalize and/or criterion reference reading comprehension abilities has been a difficult task. A Branch supported Small Business Innovative Research grant has developed a computer based reading scale that assigns comprehension difficulties to a wide variety of commonly read texts. The scale was constructed by using a two component model using measures of syntactic and semantic difficulty. Textual materials were then subjected to an analysis for difficulty level. Reading materials were classified on a scale ranging from 100 to 1100, primer texts at the low end and encyclopedia text at the high end. By reanalyzing the results of nationally standardized reading comprehension tests with his scaling technique, the investigator was able to construct a "universal norm" based on a population of over 200,000 students. This reading comprehension scale may provide other investigators with a reliable method to categorize subjects into ability levels based on reading comprehension for familiar text. The scale may provide teachers a pragmatic test for assessing which reading materials students are most likely to comprehend at different stages of their development.

Reading - Problems of Measurement

As these studies illustrate, the ability to read requires a basal level of proficiency in numerous sub-skills, some of which appear to be "hard-wired"

while others may be susceptible to change through environmental manipulations, or "soft-wired." The results of the variability in both biological capacities and environmental exposures is that reading skills vary greatly within the human population not only between different individuals, but also within the same individual at different times during his/her development. The definition and measurement of reading ability is complicated by these factors and such other factors as the age of the subject, the measurement tools, general cognitive deficits, gender differences, and cultural differences. Attempts to define and measure reading ability have resulted in little agreement between scientists in inclusive and exclusive definitional boundaries, incidence and prevalence estimates, descriptions of poor readers, and the nature of the etiology and treatment of poor reading. These factors are, in large part, responsible for the great variety of subgroups of reading disabilities reported in the literature.

In a study designed to compare the predictive validity for selection of dyslexic boys at different ages, verbal reports by teachers and parents, standard neuropsychological tests, and neurophysiological electroencephalographic examinations were used. This investigator studied boys who were identified in kindergarten as at risk for dyslexia by teacher ratings and standardized tests mandated for school entry. None of these boys showed evidence of neurological impairment, emotional disorder, systemic diseases known to inhibit intellectual development, nor genetic anomalies associated with mental retardation. The investigator administered a battery of neuropsychological and neurological tests to the at risk and normal control groups when they were in kindergarten, second grade and fourth grade. Teacher ratings of boys at risk were very accurate in predicting the poorest performing boys when they were measured in second grade. The neuropsychological measures identified 80% of the poor performers and 83% of the non-disabled performers in second grade. Preliminary results of a pilot study by this investigator using neurophysiological tests of spontaneous EEG and sensory evoked potentials show different brain electrical functional mapping for phonemic, anomic and global language disordered individuals. The results of studies such as this will provide a basis for building a nosology of reading disability.

Reading - Biological Explanations for Variability: Neurology

In order to tie the abnormalities observed in reading disabilities to the biological underpinnings of those affected individuals, Dr. Geschwind proposed a theory that, if substantiated, may tie together a number of observations commonly made about poor readers. Poor readers (dyslexics) have been characterized as more often immune deficient, exhibiting unusual cerebral dominance, left-handed, and perhaps having abnormally developed portions of their brain. The theory holds that an abnormality in hormone levels during early development may affect the development of the immune system, endocrine system and CNS structural development which subsequently lead to different developmental paths some of which terminate in the inability to read. The fact that in most humans the left hemisphere mediates the speech reception and expression capacities fits this theory since this in the general area where the structural abnormalities of the brain have been discovered.

A study of several brains of deceased dyslexic individuals has shown a pattern of unusual left hemisphere ectopias and dysplasias. Rather unexpectedly, a researcher supported by the Branch has discovered a strain of mice (New Zealand Black, NZB) that exhibit learning disorders, immune deficiencies and abnormal brain development which parallels that observed in the brains of the autopsied dyslexics. The next step in developing an animal model of dyslexia is to create a variety of inbred strains with different immune deficiencies and examine the differences in learning ability and brain anomalies. Isolation of these recombinant strains will offer the possibility of linking the phenotypically observable immune deficiencies and associated learning disabilities with the underlying genetic loci involved.

The frontier of measuring brain behavior relationships involved in reading and the development of reading skills is being explored by several other Branch supported researchers. A study of dyslexic and normal readers on their electrophysiological responsiveness to auditory and visual stimulation found much greater left than right hemisphere activation. This indicates that dyslexics may be working harder on decoding the written message into the sound code than normal readers who may be activating regions of the brain which process the materials for meaning. A study comparing topographical maps of brain functioning of normal readers and dyslexics found qualitative differences in the left hemisphere speech and language regions of the dyslexics.

Reading - Biological Explanations for Variability: Genetics

For many years, evidence has been accumulating that the causes of some individuals' inability to read has both genetic and environmental components. A study sponsored by the NICHD for eleven years has used a variety of genetic methods to examine the hypothesis that at least some part of the explanation for reading deficiency is explained by genetic differences. Using a family studies approach the investigators conclusively demonstrated a familial component to reading disability. Since family members share both genetic and environmental influences, these findings alone do not provide sufficient evidence of a genetic component to reading disability.

In order to demonstrate a genetic component to this finding of familial influence, these investigators have examined reading skills through the use of twin study and chromosomal linkage methods. By examining the concordance rates for reading disability in identical (MZ) and fraternal (DZ) twins, an estimate of the genetic (heritable) component of reading deficits was estimated to be approximately 30%. Another study used probability studies to examine the possibility of genetic linkage of a specific type of reading disability with a cytological marker on chromosome 15. This apparently autosomal dominant transmitted type of reading disability was found to be linked to chromosome 15. Independent studies are currently being supported to confirm or refute this finding.

Given variability in the development of reading abilities, measuring reading skills at different ages could produce different genetic loadings

for component skills. If phonological processing skills are important in the development of language and the capacity for categorizing acoustical signals into elementary units is present very early in development, then one might ask to what degree this specific reading characteristic is heritable. One study recently showed that while visual coding skills are not heritable, some precursors of the phonological coding skill may have a significant genetic component. Studies of reading performance, symbol-processing speed, and spatial/reasoning have found that disabled readers perform worse than normal readers on all measures. While the rate of improvement of disabled and non-disabled readers was similar for reading performance and spatial/reasoning measures, the disabled readers did not improve at a comparable rate to non-disabled readers in their ability to rapidly process symbols. This finding argues for differential developmental capacities for the component skills that are necessary for proficient reading. The results support the hypothesis that there may be different genetic influences for these component processes and probably differential effectiveness in remediation of the various deficiencies.

Future Areas of Emphasis

The inability of scientists and educators to agree upon a useful, valid, and reliable definition of learning disability has resulted in great difficulty in comparing findings of studies of poor readers. In light of the emergence of new methods for examining the relationships between biological responses and environmental events, Geschwind's theoretical work, and the result of twenty years of research on the normal development of reading, the NICHD held a conference in 1985 to discuss the possibility of investigating ways of anchoring definitions of dyslexia to potential biological contributors to the etiology of dyslexia. As a result of this conference, a request for applications (RFA) entitled "Defining and Subtyping Dyslexia" was issued by the NICHD.

Over the past two years, three program projects have been awarded that address many of the problems which have hindered progress in better understanding dyslexia. A primary thrust of these projects is the establishment of a definition and nosology of dyslexia. Populations selected and unselected for reading disability are being assessed by using standardized tests of intelligence and reading, continuous performance measures of reading over development, specific tests of phonological, syntactic and semantic abilities, and experimental tests of cognitive processes involved in reading comprehension. The results of these studies will provide some preliminary estimates of the frequency of dyslexia. Central to all three program projects are studies which assess genetic contributions to reading deficiencies through chromosomal linkage analysis, restriction fragment length polymorphism techniques, and family and twin methods. The projects are examining brain activity correlates with reading through magnetic resonance imaging, positron emission tomography, computerized axial tomography, and electrophysiological records of brain activity. Two projects are testing Geschwind's theory by analyzing the relationships between poor readers and their endocrine and immune deficiencies, cerebral dominance, and handedness.

The Health Research Extension Act of 1985 (P.L. 99-158) mandated the establishment of an Interagency Committee on Learning Disabilities (ICLD) for the purpose of reviewing and assessing "Federal research priorities, activities, and findings regarding Learning Disabilities (including central nervous system dysfunction in children)." The NICHD was designated the lead agency for this congressional initiative. The ICLD held a public forum to solicit input on the nature of the problem and directions for future research. Learning disabled individuals, their families, teachers, administrators, advocacy organizations, practitioners, and scientists made formal presentations to the committee. The NICHD collected and analyzed the currently supported Federal research in learning disabilities for the ICLD. In January of 1986, a National Conference on Learning Disabilities was held to discuss the current state of knowledge, identify gaps, and make recommendations for future research.

The products of these three events were summarized in a book entitled "Learning Disabilities: A Report to the U.S. Congress." The recommendations of this report include the use of a new definition of learning disability, the development of a classification system for learning disabilities, the creation of large program projects and research centers to examine the prevalence, etiology, effects of early intervention, effectiveness of differential remediation programs, and long term studies of the development and consequences of learning disabilities. Perhaps the most significant action recommended in this report to Congress is that the definition of learning disabilities be changed to include the following seven general areas--listening, speaking, reading, writing, reasoning, mathematics, and social abilities. The HLB Branch is developing a plan for the implementation of this report. Several workshops will be held in FY88 which will focus on developing reliable and valid assessment methods for measuring the capacities of learning disabled individuals in each of the seven domains proscribed in the new definition of learning disability.

## CONFERENCES

During the past three fiscal years the Branch sponsored a number of workshops and conferences to highlight the research findings of our grantees and to help advance the state of the sciences in behavioral development.

In FY 85 the Branch sponsored two conferences:

(1) The Impact of Divorce, Single Parenting and Step Parenting in Children was held in May 1985. The focus of the meeting was upon the consequences of these events and associated child rearing practices on child development.

(2) Psychobiological Aspects of Behavioral Development was held in September 1985. The focus of the meeting was upon behavioral development early in life. Research on prenatal and early postnatal development of animal and human babies was discussed and evaluated. A book based on the conference was published in June of 1987. Krasnegor, N.A.; Blass, E.; Hofer, M. and Smotherman, W. (eds): Perinatal Development: A Psychobiological Perspective, Orlando, Florida: Academic Press.

In FY 86 two conferences and two workshops were conducted:

(1) Childhood Obesity (April 1986) - The focus of the workshop was upon biobehavioral determinants and treatment strategies for preventing obesity in childhood. The meeting was jointly sponsored by the HLB Branch and the ENG Branch. A book based upon the conference is in press. Krasnegor, N.A.; Grave, G. and Kretchmer, N. (eds): Childhood Obesity: A Biobehavioral Perspective, New Jersey: Telford Press.

(2) Minority Families and Children (May 1986) - The focus of this conference was upon the social and emotional patterns of development within the family of minority children (Afro-Americans, Asian Americans, Hispanic Americans and Native Americans). This conference was the basis for developing and issuing an RFA on the topic of development in minority children.

(3) Approaches to Research in Childhood Injury (September 1986) - This workshop focused upon methods that need to be developed by researchers who study childhood injury. An article based upon this workshop has been submitted for publication in the pediatric literature. Scheidt, P. Behavioral Research Toward Prevention of Childhood Injury.

In FY 87 two conferences and one workshop were sponsored by the Branch.

(1) Continuity in Development (April, 1987) - The focus of this conference was on the analysis of ten longtudinal data sets on cognitive development in children. The data were assessed from the perspectives of intelligence, measurement theory, and behavior genetics. A book based on the conference is in press. Bornstein, M. and Krasnegor, N.A. (eds) Continuity in Cognitive Development, Hillsdale, New Jersey: Erlbaum.

(2) Biobehavioral Concepts in Development (June 1987) - This workshop focused upon bridging fields of inquiry of psychobiology, ethology, and developmental psychology. The meeting is viewed as the first of a series which provides a forum for comparing and contrasting research ideas in these diverse fields.

(3) Biological and Behavioral Aspects of Parenting in Mammals (September 1987) - This conference focused upon the hormonal and behavioral bases for the initiation of parenting in mammals. The topic is summarized in an edited book that is in press. Krasnegor, N.A. and Bridges, R. (eds): Biological and Behavioral Aspects of Parenting in Mammals, New York, New York: Oxford University Press.

## REQUESTS FOR APPLICATIONS

The Branch has published three Requests for Applications (RFAs) since the last report to Council.

FY 85

Defining Subtypes of Dyslexia - This RFA was designed to stimulate the submission of program projects on the topic of sub-typing dyslexia. Three grants have been made: Bowman Gray Medical School, Yale University Medical School and the Mailman Center of the University of Miami.

Injury and Injury Prevention in Children - This RFA was designed to stimulate and fund research directed at the prevention of unintentional injury to children. Four grants have been made, one from the original submission and three from resubmitting of original applications.

FY 87

Minority Families and Children: Behavioral and Societal Variables Affecting Children's Development - This RFA was designed to stimulate research among Afro-Americans, Asian-Americans, Hispanic Americans and Native Americans on family processes including commonalities and differences within and between ethnic groups; behavioral development covering cognitive and social development, and the interaction of health and behavior in development. Some fifty applications were received and reviewed. The meritorious applications are to be reviewed by the National Advisory Child Health and Human Development Council at its January 1988 meeting.

## STAFF CHANGES

### Professional Staff

Since the last report to Council several staff changes have occurred:

Dr. Peter Scheidt, a pediatrician and medical officer in the Public Health Service, joined the Branch in January of 1986. Dr. Scheidt is responsible for the behavioral pediatrics section of the Branch portfolio.

Dr. Josephine Arasteh retired from Federal service in June of 1986. She is now living with her family in California.

Dr. Sarah Friedman, a developmental psychologist, joined the Branch staff in January of 1987. She is a Health Scientist Administrator who is responsible for the cognitive and social-emotional aspects of the Branch portfolio.

Dr. David Gray left in March 1986 to become Director of the National Institute of Disability and Rehabilitation Research (NIDRR) in the Department of Education. He returned in October of 1987 and is responsible for the communications and learning disabilities aspects of the Branch portfolio.

### Support Staff

Our Branch secretary, Ms. Mary McIntosh, transferred from the NICHD to the Division of Research Grants in 1987.

Ms. Debbie Eyler joined the Branch as a clerk typist in March of 1987.

Ms. Marsha Sotzsky became Branch secretary in April of 1987.

TABLE 1: NICHD, CRMC, AND HLB PROJECTS: NUMBER AND FUNDS

FY 1978 - FY 1987

| Fiscal Year | NUMBER OF PROJECTS | | | FUNDS (In Thousands) | | |
|---|---|---|---|---|---|---|
| | NICHD | CRMC | HLB | NICHD | CRMC | HLB |
| 1978 | 1,560 | 849 | 106 | $137,300 | $80,665 | $7,242 |
| 1979 | 1,748 | 989 | 141 | 165,960 | 101,627 | 12,013 |
| 1980 | 1,759 | 993 | 127 | 174,748 | 100,783 | 12,099 |
| 1981 | 1,671 | 939 | 134 | 182,789 | 105,618 | 12,446 |
| 1982 | 1,696 | 934 | 132 | 185,064 | 105,082 | 12,551 |
| 1983 | 1,799 | 1,020 | 151 | 208,482 | 122,606 | 14,473 |
| 1984 | 1,832 | 1,053 | 154 | 225,605 | 135,004 | 15,222 |
| 1985 | 1,931 | 1,149 | 176 | 258,749 | 157,187 | 17,179 |
| 1986 | 1,937 | 1,163 | 189 | 257,630 | 156,974 | 19,998 |
| 1987 | 2,085 | 1,273 | 214 | 308,643 | 190,138 | 24,386 |

Note: Scientific Evaluation grants are excluded.

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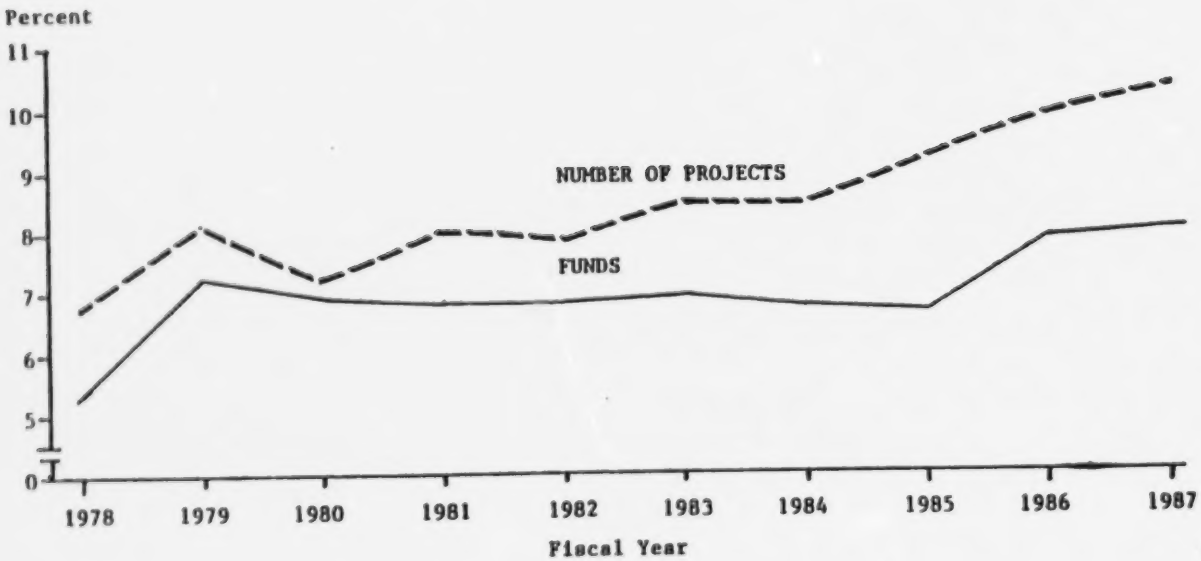
Figure 1

## HLB AS A PROPORTION OF NICHD, FY 1978 - FY 1987




Note: Scientific evaluation grants are excluded.

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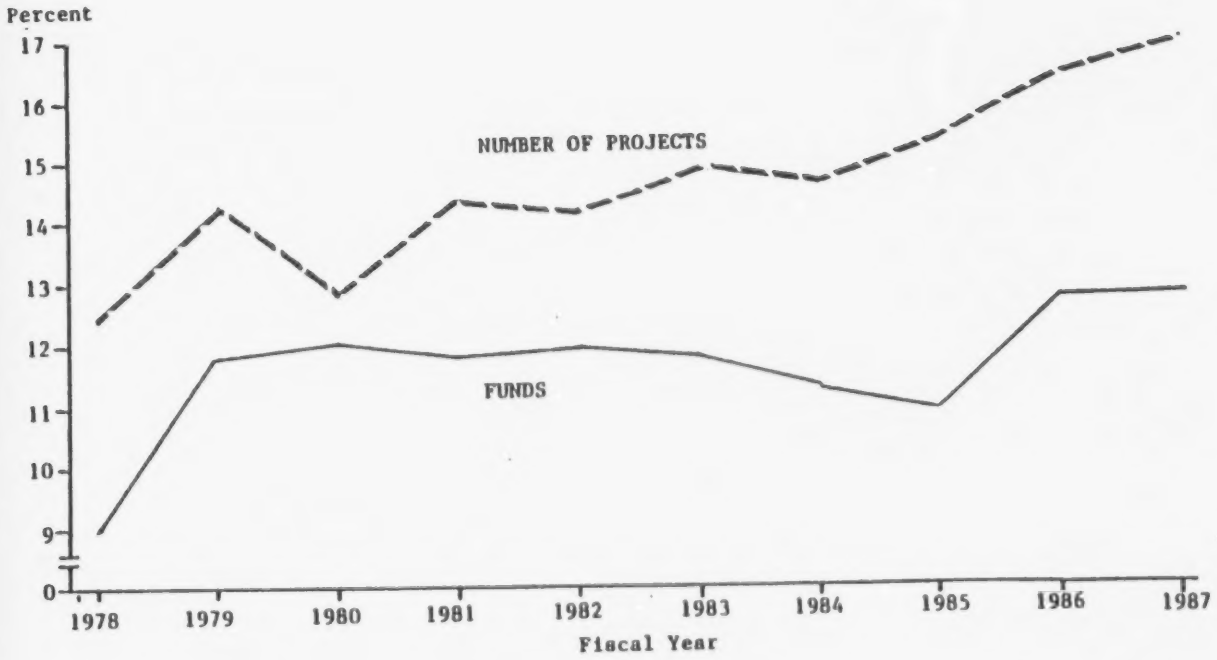
Figure 2

## HLB AS A PROPORTION OF CRMC, FY 1978 - FY 1987




Note: Scientific evaluation grants are excluded

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TABLE 2: NUMBER OF HLB GRANTS FUNDED, BY MECHANISM

FY 1980 - FY 1987

| Fiscal Year | Total | Research Grants | Program Projects | Career Awards | Training | Contracts |
|---|---|---|---|---|---|---|
| 1980 | 127 | 95 | 8 | 5 | 16 | 3 |
| 1981 | 134 | 108 | 7 | 5 | 13 | 1 |
| 1982 | 132 | 102 | 7 | 4 | 18 | 1 |
| 1983 | 151 | 117 | 7 | 7 | 19 | 1 |
| 1984 | 154 | 120 | 6 | 6 | 21 | 1 |
| 1985 | 176 | 135 | 4 | 7 | 29 | 1 |
| 1986 | 189 | 142 | 7 | 12 | 27 | 1 |
| 1987 | 214 | 154 | 9 | 12 | 32 | 3 |

Note: Scientific Evaluation grants are excluded.

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TABLE 3: EXPENDITURE OF HLB FUNDS, BY MECHANISM

FY 1980 - FY 1987
(Funds in Thousands)

| Fiscal Year | Total | Research Grants | Program Projects | Career Awards | Training Grants | Contracts |
|---|---|---|---|---|---|---|
| 1980 | $12,099 | $7,301 | $3,072 | $189 | $908 | $629 |
| 1981 | 12,446 | 8,214 | 3,070 | 193 | 877 | 92 |
| 1982 | 12,551 | 8,220 | 3,291 | 154 | 778 | 109 |
| 1983 | 14,473 | 9,955 | 3,167 | 273 | 999 | 78 |
| 1984 | 15,222 | 10,851 | 3,008 | 233 | 1,083 | 46 |
| 1985 | 17,179 | 13,040 | 2,103 | 367 | 1,579 | 90 |
| 1986 | 19,998 | 13,349 | 4,131 | 638 | 1,782 | 98 |
| 1987 | 24,386 | 15,767 | 5,815 | 602 | 1,979 | 223 |

Note: Scientific Evaluation grants are excluded.

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Figure 3

# NUMBER OF HLB GRANTS FUNDED, BY MECHANISM
## FY 1980 - FY 1987

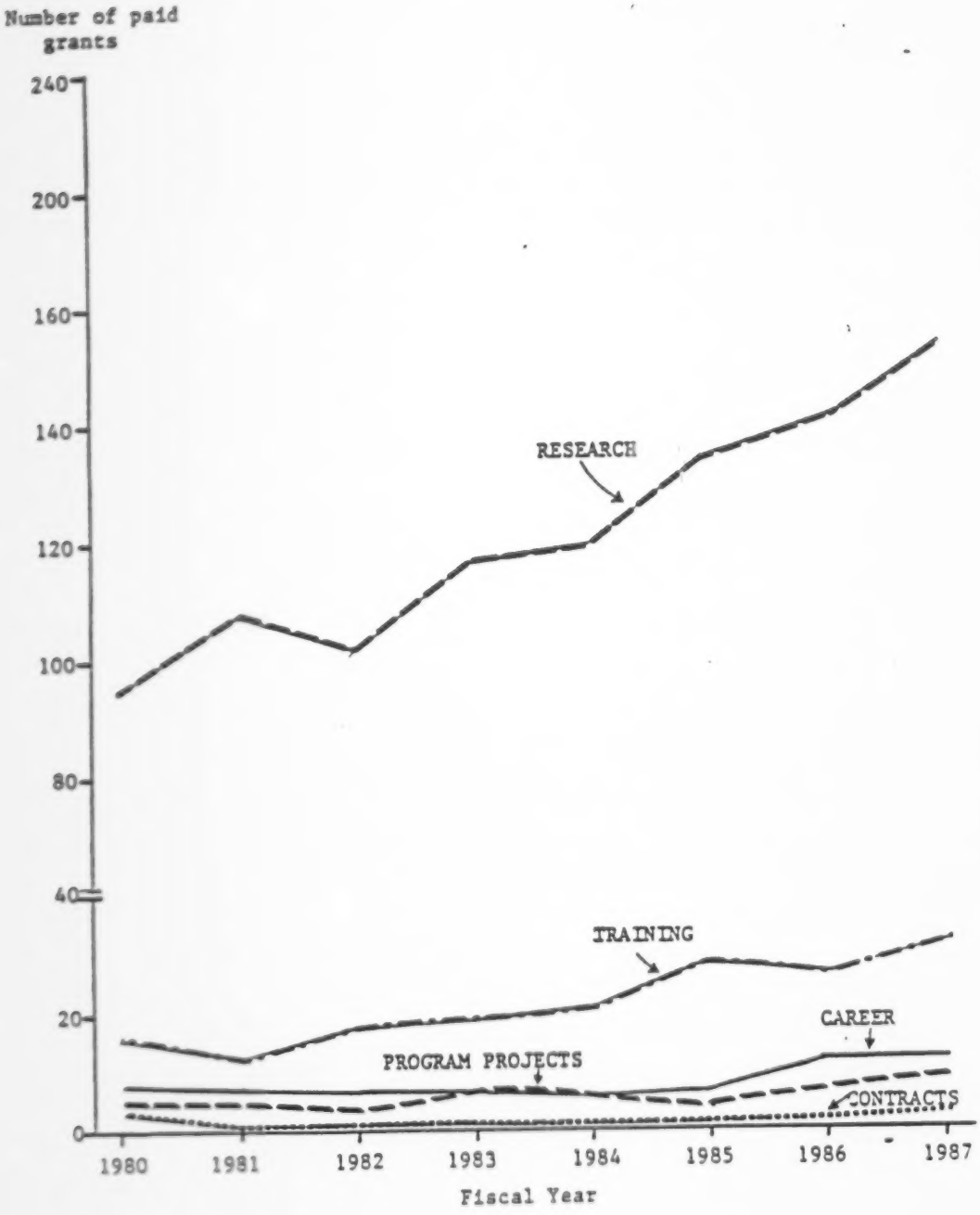


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Figure 4

# HLB FUNDS BY PROGRAM CATEGORY, FY 1978 - FY 1987

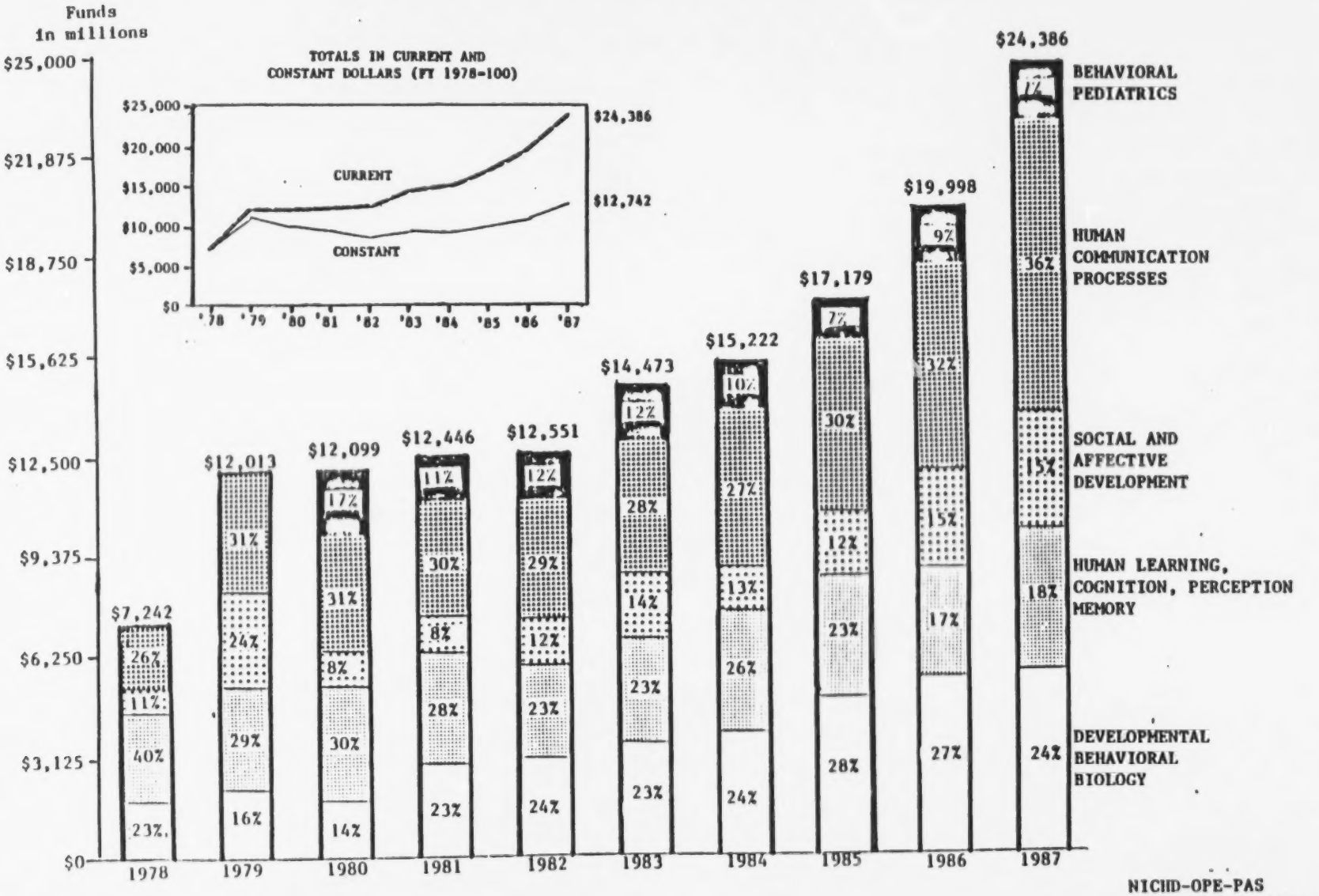


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TABLE 4: HLB GRANTS BY NUMBER AND FUNDS IN CURRENT AND CONSTANT DOLLARS

FY 1978 - FY 1987

| Fiscal Year | NUMBER OF PROJECTS | FUNDS (in Thousands) | |
|---|---|---|---|
| | | Current Dollars | Constant Dollars* |
| 1978 | 106 | $ 7,242 | $ 7,242 |
| 1979 | 141 | 12,013 | 11,100 |
| 1980 | 127 | 12,099 | 10,139 |
| 1981 | 134 | 12,446 | 9,425 |
| 1982 | 132 | 12,551 | 8,738 |
| 1983 | 151 | 14,473 | 9,442 |
| 1984 | 154 | 15,222 | 9,325 |
| 1985 | 176 | 17,179 | 9,957 |
| 1986 | 189 | 19,998 | 11,087 |
| 1987a/ | 214 | 24,386 | 12,742 |

Note: Scientific Evaluation grants are excluded. NICHD-OPE-PAS
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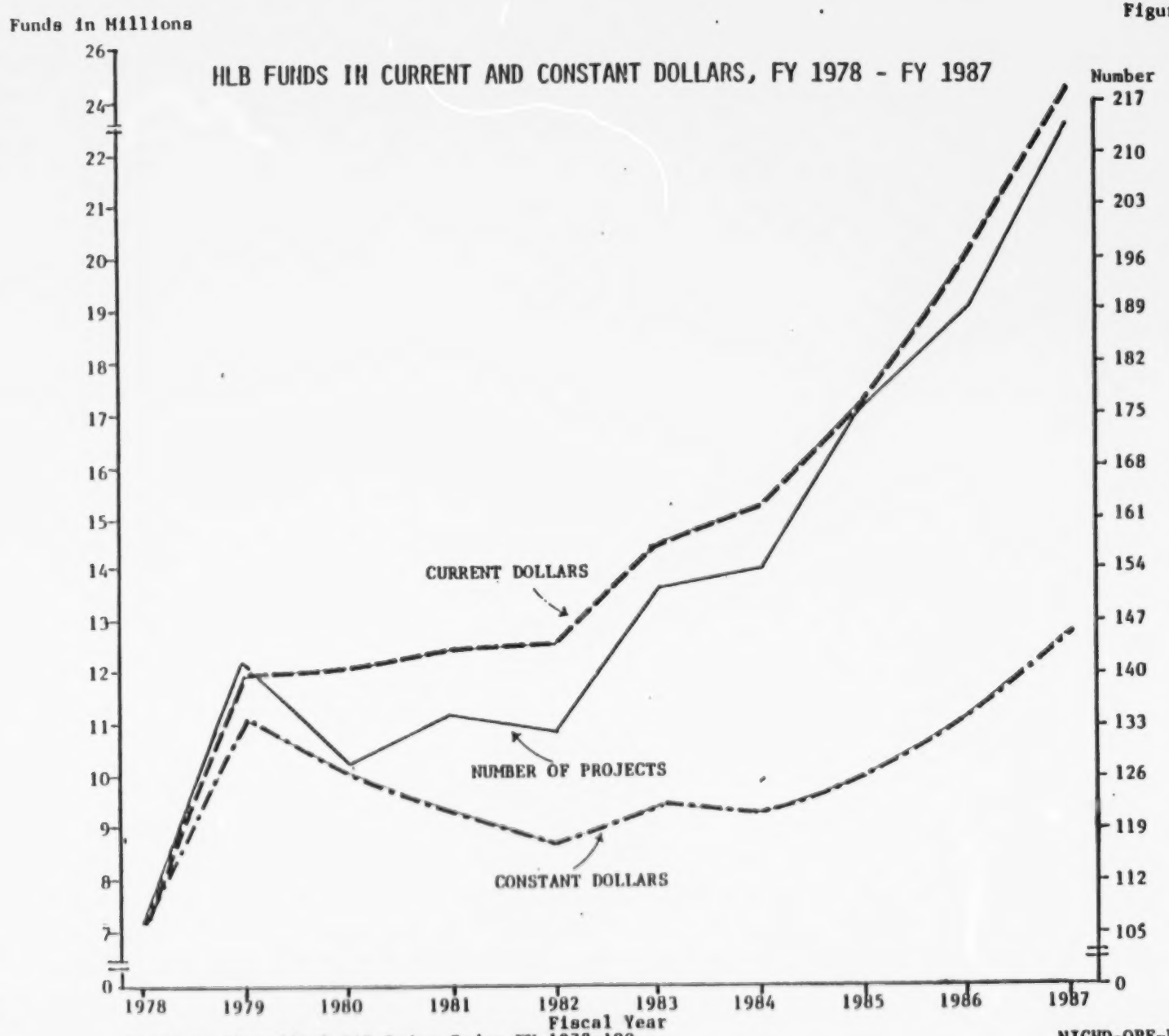
a/ Preliminary

*Based on Biomedical R&D Price Index FY 1978 = 100.

Figure 5




Based on Biomedical R&D Price Index FY 1978=100
Note: Scientific Evaluation Grants are Excluded
a/ Preliminary

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TABLE 5: HLB GRANTS BY NUMBER AND FUNDS IN CONSTANT DOLLARS BY PROGRAM CATEGORY
FY 1978 - FY 1987
(Funds in Thousands)

| Fiscal Year | Total | | Developmental Behavioral Biology | | Human Learning Cognition, Perception, Memory | | Social & Affective Development | | Human Communicative Processes | | Behavioral Pediatrics | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Funds* | Number | Funds* | Number | Funds* | Number | Funds* | Number | Funds* | Number | Funds* |
| 1978 | 106 | $7,242 | 31 | $1,706 | 44 | $2,902 | 11 | $786 | 20 | $1,848 | - | - |
| 1979 | 141 | 11,100 | 31 | 1,824 | 48 | 3,174 | 30 | 2,647 | 32 | 3,455 | - | - |
| 1980 | 127 | 10,139 | 25 | 1,461 | 42 | 3,016 | 12 | 781 | 29 | 3,196 | 19 | $1,684 |
| 1981 | 134 | 9,425 | 34 | 2,126 | 41 | 2,668 | 14 | 804 | 30 | 2,820 | 15 | 1,007 |
| 1982 | 132 | 8,738 | 44 | 2,110 | 30 | 2,001 | 18 | 1,004 | 28 | 2,557 | 12 | 1,066 |
| 1983 | 151 | 9,442 | 43 | 2,234 | 36 | 2,156 | 21 | 1,282 | 35 | 2,646 | 16 | 1,123 |
| 1984 | 154 | 9,325 | 43 | 2,281 | 42 | 2,374 | 21 | 1,177 | 33 | 2,542 | 15 | 952 |
| 1985 | 176 | 9,957 | 51 | 2,789 | 51 | 2,270 | 20 | 1,178 | 42 | 2,984 | 12 | 735 |
| 1986 | 189 | 11,087 | 54 | 3,031 | 45 | 1,906 | 30 | 1,646 | 43 | 3,558 | 17 | 947 |
| 1987a/ | 214 | 12,742 | 52 | 2,966 | 61 | 2,312 | 37 | 1,920 | 46 | 4,610 | 18 | 934 |

Note: Scientific Evaluation grants are excluded.
a/ Preliminary
* Based on Biomedical R&D Price Index FY 1978 = 100.

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TABLE 6: HLB NUMBER OF APPLICATIONS REVIEWED, APPROVED, FUNDED BY SELECTED STUDY SECTIONS
FY 1978 - FY 1987

| Fiscal Year | Total | | | Behavioral Medicine | | | Bio-Psychology | | | Sensory Disorders & Language | | | Human Development & Aging | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Review-ed | Approved | Funded | Review-ed | Approved | Funded | Review-ed | Approved | Funded | Review-ed | Approved | Funded | Review-ed | Approved | Funded |
| 1978 | 13 | 8 | 2 | - | - | - | - | - | - | 13 | 8 | 2 | - | - | - |
| 1979 | 85 | 38 | 21 | - | - | - | 9 | 8 | 3 | 18 | 13 | 7 | 58 | 17 | 11 |
| 1980 | 130 | 72 | 22 | 7 | 5 | 3 | 17 | 17 | 6 | 13 | 7 | - | 93 | 43 | 13 |
| 1981 | 142 | 75 | 35 | 11 | 3 | - | 18 | 14 | 9 | 16 | 13 | 6 | 97 | 45 | 20 |
| 1982 | 182 | 113 | 38 | 15 | 9 | 4 | 31 | 30 | 10 | 19 | 14 | 3 | 117 | 60 | 21 |
| 1983 | 235 | 150 | 40 | 28 | 19 | 6 | 20 | 18 | 3 | 23 | 15 | 3 | 164 | 98 | 28 |
| 1984 | 221 | 156 | 36 | 29 | 13 | 4 | 27 | 24 | 5 | 22 | 14 | 3 | 143 | 105 | 24 |
| 1985 | 248 | 214 | 54 | 16 | 13 | 3 | 36 | 31 | 8 | 24 | 19 | 5 | 172 | 151 | 38 |
| 1986 | 239 | 204 | 49 | 15 | 13 | - | 23 | 21 | 4 | 17 | 16 | 6 | 184 | 154 | 39 |
| 1987 | 184 | 168 | 52 | 12 | 11 | 3 | 15 | 12 | 2 | 11 | 10 | 5 | 146 | 135 | 42 |

Source: IMPAC -- SAB/DRG -- IRS PROGRAM JGCJJ114

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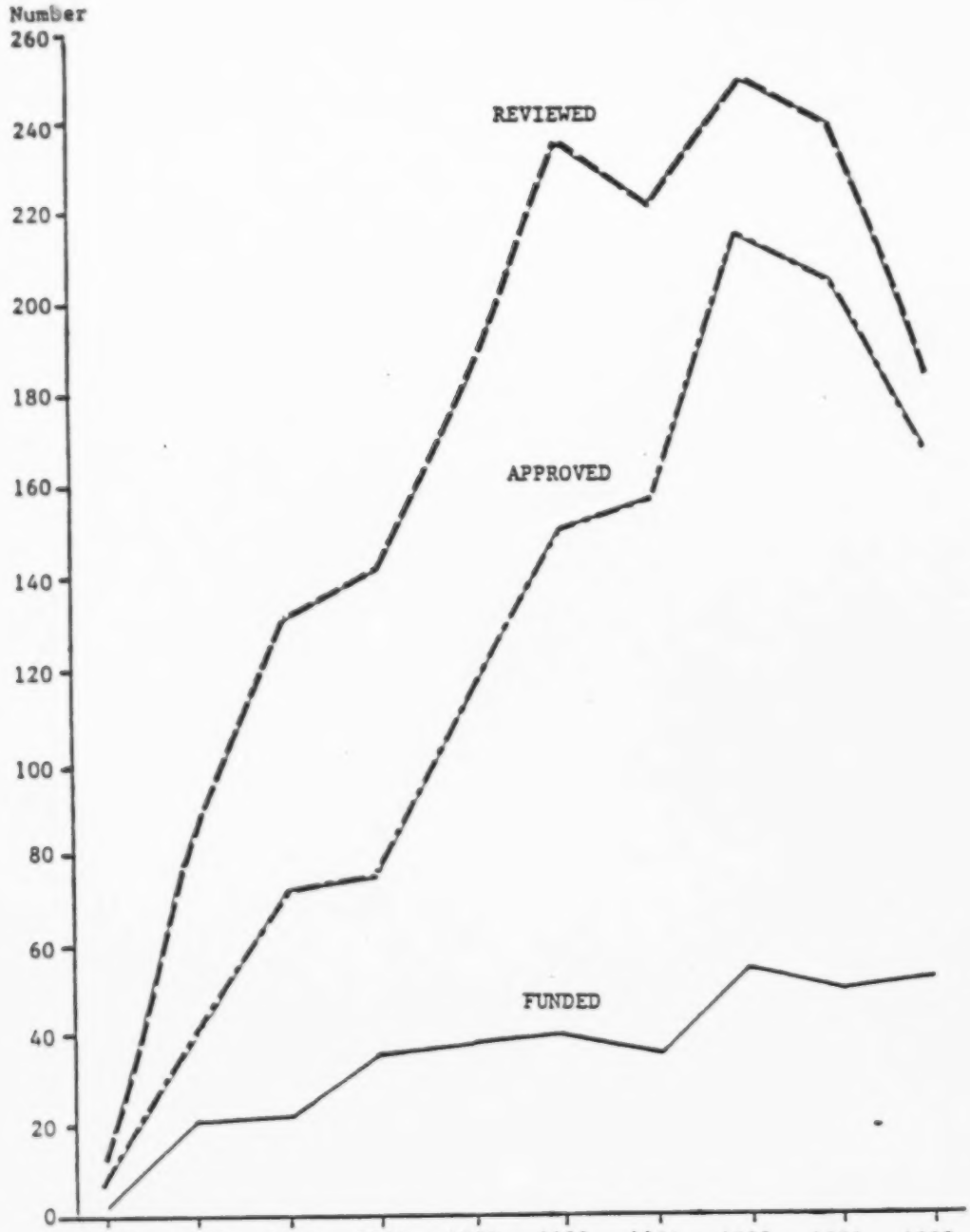
December 21, 1987

Figure 6

# HLB APPLICATIONS REVIEWED, APPROVED AND FUNDED, FY 1978 - FY 1987

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December 21, 1987

SOURCE: IMPAC--SAB/DRG---
IRS PROGRAM JGCJJ114

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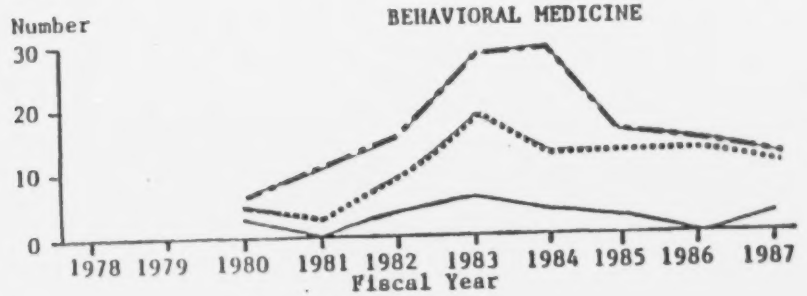
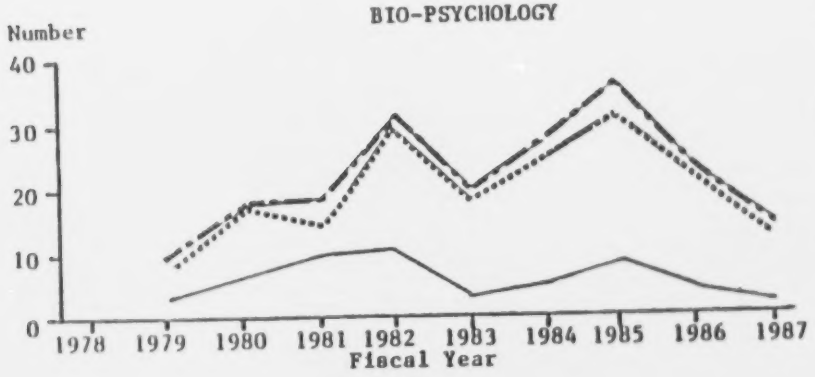
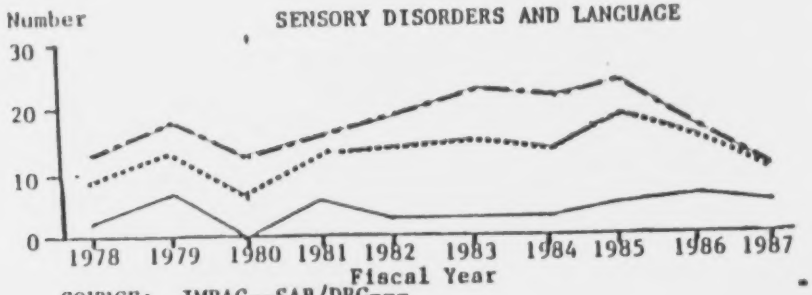
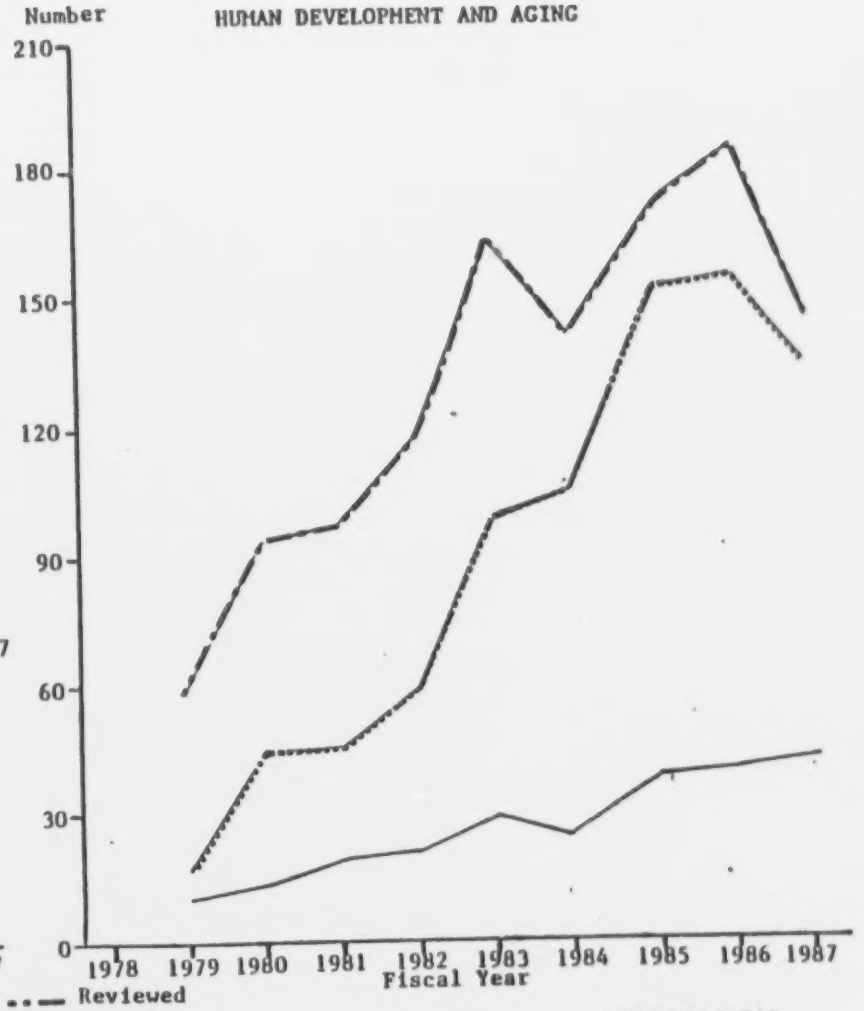
December 21, 1987

# HLB APPLICATIONS REVIEWED, APPROVED, FUNDED BY SELECTED IRG'S, FY 1978 - FY 1987




SOURCE: IMPAC--SAB/DRG---
IRS PROGRAM JGCJJ114

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